DATA PROCESSING

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196 **Preparing sales quotations promptly**
how two operators with Flexowriters now produce all the documents formerly prepared by five typists

204 **Electronic record-keeping**
an inexpensive machine for the smaller business that can keep track of 5,000 stock records

208 **Machine reading**
a survey of the printed codes that can be read directly by both men and machines

224 **Thermoplastic recording**
a new method of storing vast quantities of information on a single plastic tape—a technique of the future!

230 **Automatically up-dating account records without a computer**
a description of a fully automatic version of a standard keyboard accounting machine

238 **Branch bank accounting**
how the Chartered Bank use two of the new generation of electronically operated keyboard accounting machines to up-date current account records

246 **Data processing topics**
comments on new equipment and important applications

248 **I.C.T.'s new computer—the 1301**

254 **Management accounting by digital computer**
a technique that enables an engineering company to maintain tighter control over the production operations of two factories

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Preparing sales quotations

At Stewarts and Lloyds' Glasgow sales offices, two operators using two Flexowriters produce the documents for sales quotations that were formerly prepared by a staff of five typists. Not only has the entire procedure been speeded up, so that now quotations are submitted by return post, but, in addition, transcription errors have been eliminated and the appearance of the quotation letters has been greatly improved. Between 50 and 60 quotations are handled each day. This article describes the procedure in detail

In Scotland, at the Glasgow sales offices of Stewarts and Lloyds Limited, two Flexowriter FPC-8 (double case) machines are used to prepare, largely automatically, all the documents needed in connection with the preparation of sales quotations. Each quotation is recorded on three documents. The same information—though occasionally modified—is printed on each, but is always arranged in a different format. A considerable amount of copy typing is involved and two operators using Flexowriters can now cope with this work which formerly required the services of five typists.

A Flexowriter is an electric typewriter equipped with a paper tape punch and a paper tape reader. Data entered on the keyboard of the machine are typed on a document in the conventional manner, and may also be punched simultaneously in paper tape. When this information is to be re-typed the punched paper tape is used to control the operation of the Flexowriter entirely automatically. A description of the Flexowriter and its various features has already been given in *Data Processing*.*

At Stewarts and Lloyds the two Flexowriters are in continuous use from 8.30 a.m. to 5.15 p.m., five days a week; two relief operators take over during the normal office lunch hour. And every day documents are prepared for between 50 and 60 quotations. At peak periods as many as 70 quotations are handled.

Besides increased productivity, other equally tangible advantages result. There is the improvement in the appearance of the quotation letters. Further, technical descriptions of the products offered for sale are now typed automatically and accurately; previously minor errors tended to creep in, especially when the typist producing the document was not familiar with the technical terms used. Also, because these descriptions are printed automatically there is no longer any need for someone to read and check, in detail, all the basic information in each quotation letter.

Savings are also made in the clerical work performed in other departments of the Company. Formerly, many of the descriptions included in a quotation were written out in long-hand and then copy typed. With the introduction of the Flexowriters the procedure for preparing quotations was re-planned and now nearly all manual writing has been eliminated.

Finally, as stated, the majority of the quotations are prepared and despatched on the same day that the letters of enquiry arrive. Before, anything from two to three days might elapse.

Enquiries for quotations are usually received by letter and the first task is to edit them. Senior clerks in the sales office do this. As is well known, Stewarts and Lloyds manufacture steel tubing in all its varied forms, and a catalogue is kept in which is recorded a full and comprehensive technical description of each type of tube made. The description does not include details of dimensions; only the specification, condition of the material and the method of manufacture are stated.

Each type of tube is identified by a code number (the catalogue contains approximately 190 of these code numbers). The clerk selects the materials which correspond with those required by the customer and writes the appropriate code number alongside each item on the enquiry letter. Finally, the clerk adds any additional instructions at the bottom of the letter, together with technical descriptions of any special items requested that are not listed in the catalogue.

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* See "Accurate copy typing at 100 words a minute", *Data Processing*, October-December, 1959.

promptly

Next, the clerk selects from a file a master-card, along the edge of which is punched the customer's name and address in the 8-channel code used by the Flexowriter. These edge-punched cards are of standard design (size: 3 inches by 7 inches) and as many as five cards may be joined, end to end, to form one master-card set. The programme to operate the Flexowriter and certain information that is to be typed on other documents prepared later in the data processing sequence are recorded in these cards in addition to the customer's name and address. On the plain portion of the first card of each set is typed the customer's name and address together with any notes or remarks of importance for either the sales clerk or the Flexowriter operator.

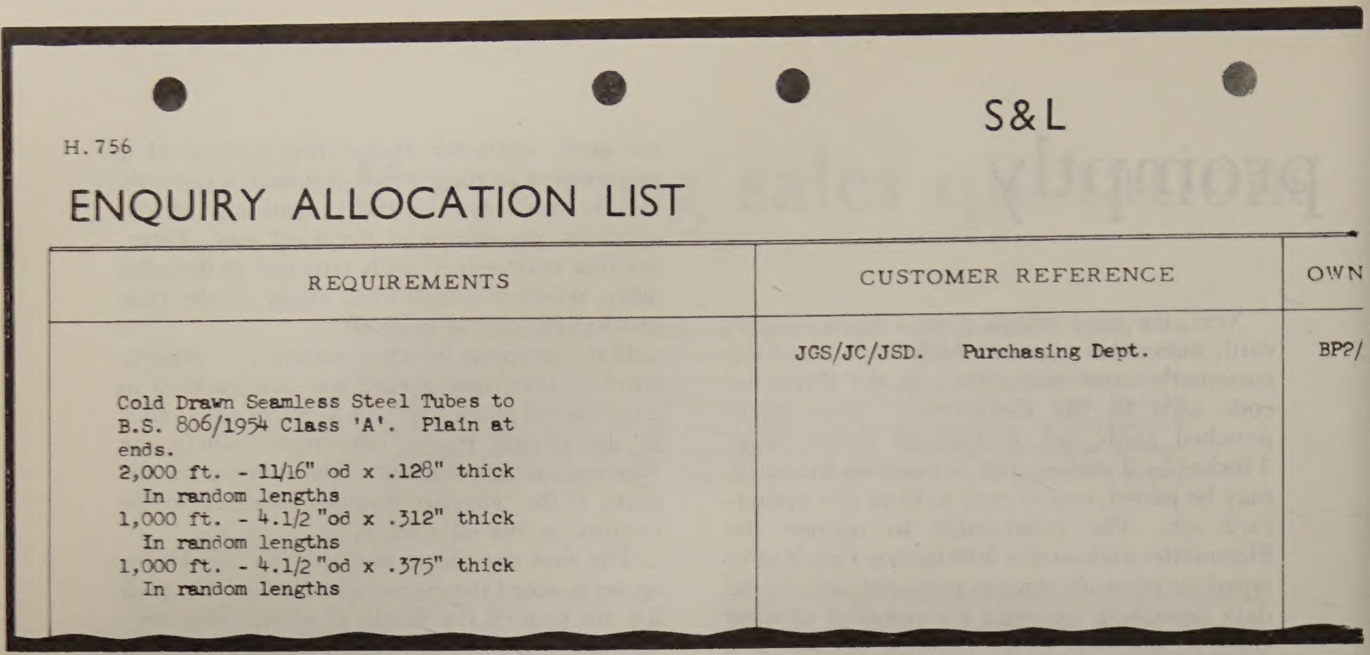
It is possible to create and maintain a file of pre-punched master cards because 95 per cent of the enquiries are submitted by regular customers. In the case of the remaining five per cent, whenever an enquiry is received a master-card set for the new customer is created; this is then used in the preparation of the quotation documents in the usual way. Later, the new master-card set is returned to the sales office, where it is filed away ready for the time another enquiry is received.

Both documents—the customer's enquiry letter and the master-card set—are enclosed in a numbered folder and sent from the sales office to the central typing department where the Flexowriters are situated. The number on the folder is the reference number allocated to the enquiry by the sales office.

The first document prepared on the Flexowriter is called the *enquiry allocation list*. On each list are printed the details of several enquiries. The list is divided into four columns entitled, from left to right, requirements, customer reference, own reference and customer.

The operator removes the master-card set from the folder and positions it in the reader of the Flexowriter. She also threads a blank paper tape through the punch and then presses the "start read" key. Immediately the Flexowriter begins to read data from the master-card set and the first action is to move the carriage so

Two operators equipped with Flexowriters perform the work of five typists



H.756

S&L

ENQUIRY ALLOCATION LIST

REQUIREMENTS	CUSTOMER REFERENCE	OWN
Cold Drawn Seamless Steel Tubes to B.S. 806/1954 Class 'A'. Plain at ends. 2,000 ft. - 11/16" od x .128" thick In random lengths 1,000 ft. - 4.1/2 "od x .312" thick In random lengths 1,000 ft. - 4.1/2 "od x .375" thick In random lengths	JGS/JC/JSD. Purchasing Dept.	BP2/

that the customer reference column of the allocation list is correctly positioned ready for the first entry.

As with conventional typewriters, the position of the carriage is controlled by a series of adjustable stops fitted to a tabulation bar attached to the rear of the Flexowriter carriage. These stops are set by hand to suit the particular programme to be performed. Whenever a tabulation code is read from the punched tape or the tabulation key is depressed the carriage is released and moves to the left automatically until halted by the next stop on the tabulation bar.

When the customer reference column has been brought into the correct position the operator types manually the reference number printed on the customer's enquiry. Then the operator presses the "start read" key again and the enquiry allocation list is moved to the next column headed "own reference." Here, the sales office reference number is entered, also manually. Following this, the customer's name and town are typed in the last column of the document; this action is performed automatically by the Flexowriter, the information being read from the master card. Although the customer's full address is recorded in the master-card set, a special code instruction ensures that only the name and town are typed. (A description of how this printing suppression feature operates is given later in the article.) The machine then stops and the operator removes the master card from the reader and returns it to the folder.

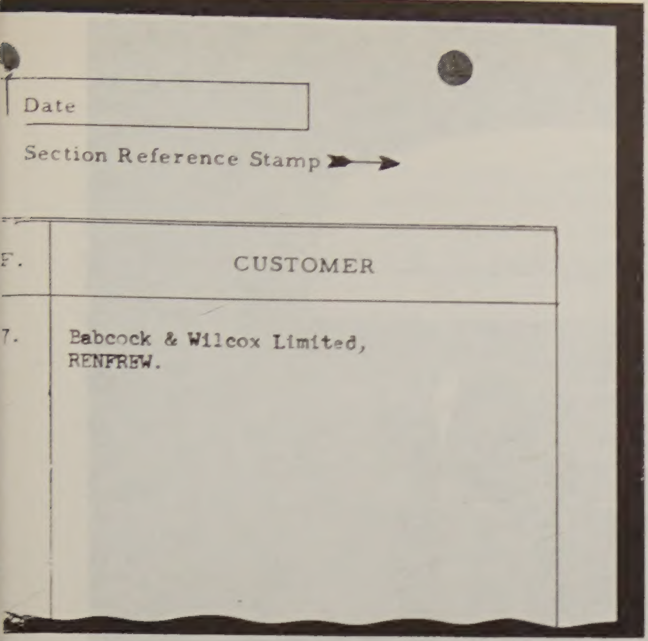
Next, she refers to the customer's letter and from a file selects an edge-punched card set which bears the same code number as that written alongside the first item in the letter.

In the card set selected is recorded a full technical description of the material as specified in the product catalogue. This product-card set is fed into the Flexowriter reader and the "start read" key is depressed once more. Immediately, the carriage is returned to the first column (the requirements column) of the enquiry allocation list and the document is fed forward one line. The technical description of the product is then typed automatically.

At the end of the description, the operator types the size and quantity of material required. For example, the description obtained from the product-card set might read "Cold Drawn Seamless Steel Tubes to B.S. 806/1954 Class 'A' Plain at ends," to which is added manually "2,000 feet—$\frac{11}{16}$ inches od × .128 inches thick. In random lengths". Proceeding in this way, the operator selects a product-card set for each item in the customer's letter and the description is automatically typed.

Two complete files of product cards are kept, one for each Flexowriter. When non-standard products are requested, the technical description of the material will have been written on the customer's letter by the sales clerk and this description is copy typed.

Six copies of the enquiry allocation list are prepared. When operated automatically, the Flexowriter makes ten strokes a second and the power behind each electrically actuated stroke

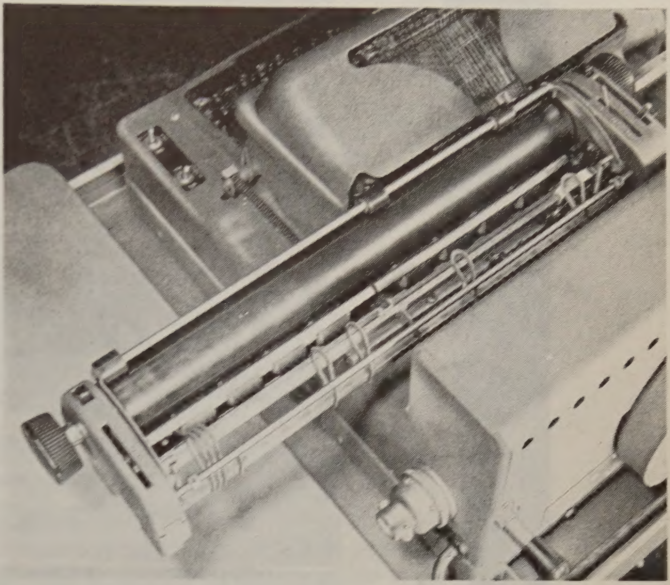


Date

Section Reference Stamp

F.	CUSTOMER
7.	Babcock & Wilcox Limited, RENFREW.

(Left) The first document prepared on the Flexowriter is the enquiry allocation list



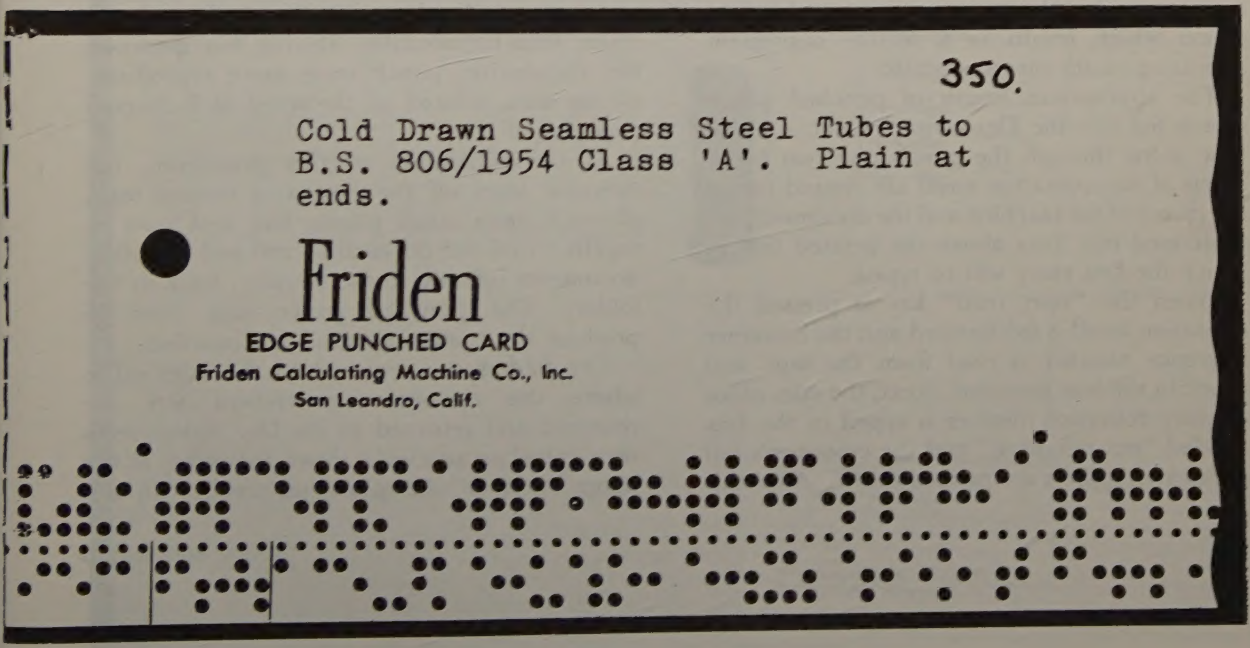
A series of stops set on a tabulation bar control the positioning of the Flexowriter carriage

is sufficient to ensure that a clear impression is made on the last carbon copy. In fact, if required, more than five legible carbon copies of a document can be prepared at a time—whether the Flexowriter is operated manually or automatically.

Throughout this entire sequence all the data read from the various edge-punched card sets together with the data entered on the keyboard are reproduced in 8-channel paper tape by the Flexowriter output punch. Included in this information is the full address of the customer plus other data such as programme instructions for later Flexowriter operations. By using the print suppression feature already mentioned, this information is not reproduced on the enquiry allocation list although it is recorded in the output tape.

After the allocation list has been typed the product-card sets are returned to their file and the tape produced by the output punch is torn off and used to prepare the next set of docu-

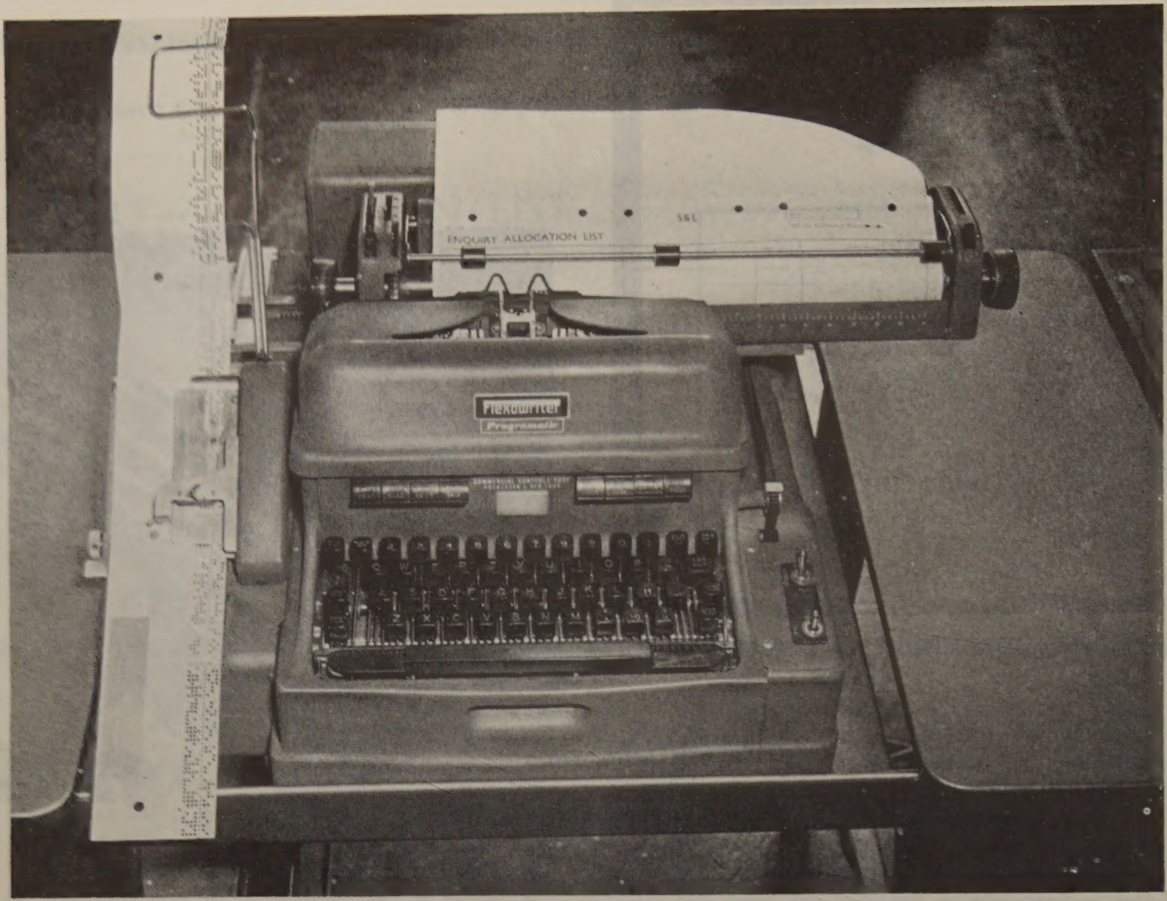
The first card of a product-card set. The technical description of the material is punched along the edge of the cards



350.

Cold Drawn Seamless Steel Tubes to
B.S. 806/1954 Class 'A'. Plain at
ends.

Friden
EDGE PUNCHED CARD
Friden Calculating Machine Co., Inc.
San Leandro, Calif.



The Flexowriter reads the data punched in the product-card set and automatically types the technical description of the material on the enquiry allocation list

ments known as quotation scrolls. Actually the output tape is divided into a number of separate lengths, each length containing the data referring to one enquiry.

A separate quotation scroll is prepared for each enquiry. Two copies of this document are produced on NCR (no carbon required) paper. With NCR paper, the pressure exerted when the type bar strikes the paper initiates a chemical action which results in a legible impression appearing on the sheets beneath.

The appropriate length of punched paper tape is fed into the Flexowriter reader, a blank tape is fed through the punch, the two blank sheets of the quotation scroll are wound round the platen of the machine and the documents are positioned two lines above the printed box in which the first entry will be typed.

When the "start read" key is pressed the quotation scroll is fed forward and the customer reference number is read from the tape and typed in the box provided. Next, the sales office enquiry reference number is typed in the box headed "our reference" and the customer's full name and address are printed below. After this a complete technical description together with the size and quantity of material required for each item on the enquiry are typed in sequence, one below the other, down the left-hand side of the quotation scroll. Thus all the data recorded on the enquiry allocation list is reproduced in the quotation scrolls. The major difference is that a separate scroll is produced for each enquiry and the data are displayed vertically rather than horizontally. During this operation the Flexowriter punch once more reproduces all the data printed on the scroll in 8-channel paper tape.

At the conclusion of this procedure, the operator tears off the length of output tape, places it in a small plastic bag and puts it, together with the quotation scroll and the other documents relating to the enquiry, back in the folder. The punched paper tape used to produce the quotation scroll is discarded.

The folders are returned to the sales office where the customer master-card sets are removed and returned to the file. Sales clerks then calculate and write down the prices of the items listed on the quotation scrolls. In addition, the time required for delivery is stated. All this information is written on the scrolls and the standard clauses covering the conditions under which the goods will be supplied are specified as well. Details of any further special conditions are also written on the scroll and the documents are passed to a second clerk who checks the information. Any errors are circled in red and the correct version written alongside. Finally, the documents in their folders are returned to the Flexowriter section for the actual quotation letters to be prepared.

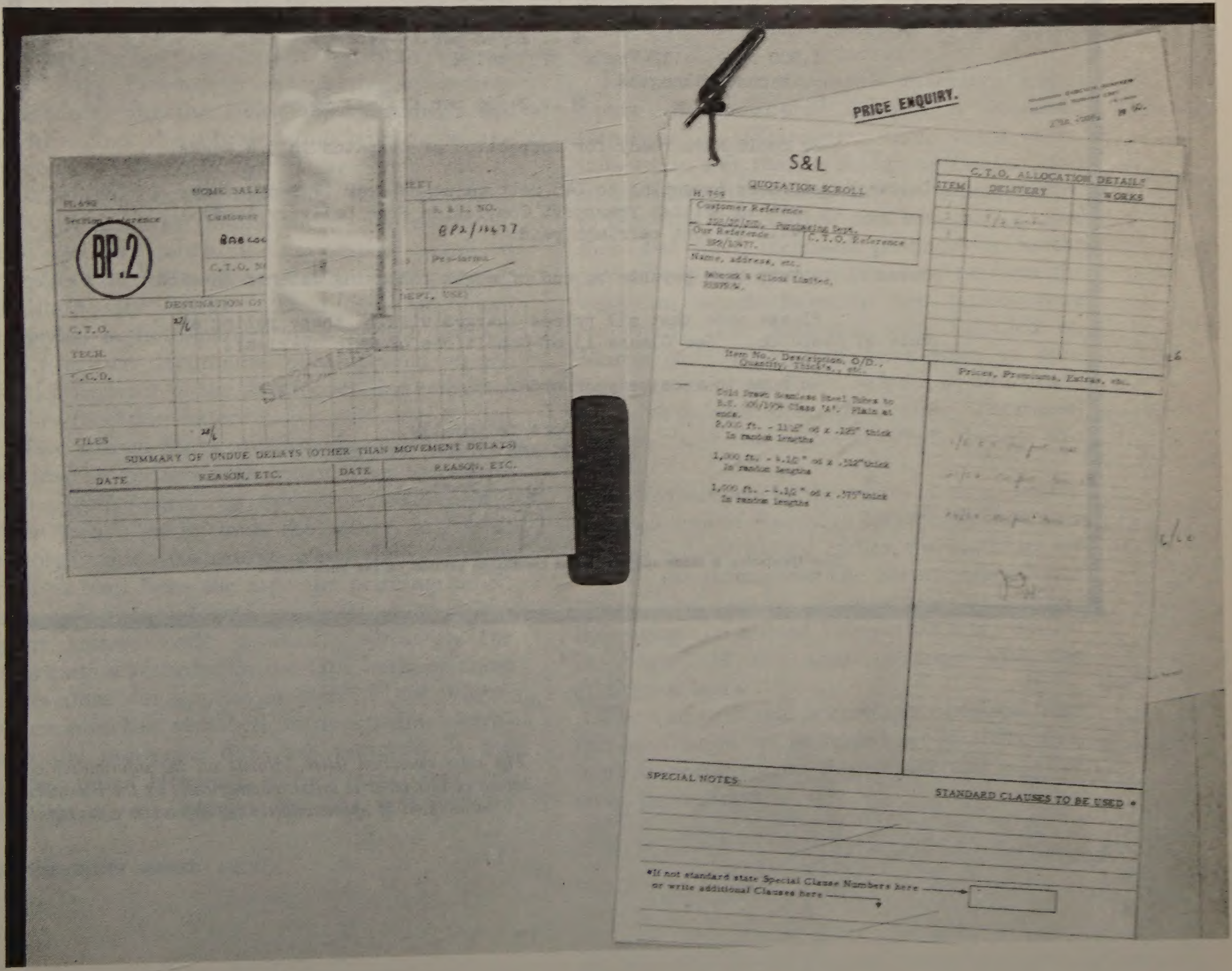
Almost the whole quotation letter is typed automatically from data obtained from the punched paper tape. Special letter paper is used on the back of which are printed the general conditions governing sales. Two copies of each letter are prepared.

The operator removes the length of punched tape from its plastic pocket and threads it through the reader of the Flexowriter. She then positions the letter paper and starts the machine. In this final sequence the tape punch is not used. First the customer's reference number, sales office reference and the customer's full name and address are typed automatically at the head of the letter. Then the carriage is moved across and the Flexowriter stops in the correct position ready for the date to be inserted manually. After this the Flexowriter takes over again and automatically prints the greeting "Dear Sir," or "Dear Sirs," as the case may be, and stops once again.

Quotation letter

The opening sentence is then typed manually. Initially, this was done automatically, but it was found that conditions varied so much from one enquiry to another that it was better for the operator to type this short sentence. After this, the descriptions of the items are typed automatically; only the price and delivery date written on the quotation scroll have to be transcribed manually. Incidentally, these data are printed in red. The operator does not have

After the items have been priced, the sales folder is returned to the Flexowriter section where the quotation letter is prepared



BP.2

Section Reference

Customer

C.T.O. No.

S. & L. NO.

Pro-forma

DESTINATION OF

DEPT. USE)

C.T.O.

TECH.

.C.D.

FILES

SUMMARY OF UNDUE DELAYS (OTHER THAN MOVEMENT DELAYS)

DATE	REASON, ETC.	DATE	REASON, ETC.

PRICE ENQUIRY.

S&L

QUOTATION SCROLL

Customer Reference

Our Reference

C.T.O. Reference

Name, address, etc.

C.T.O. ALLOCATION DETAILS

ITEM	DELIVERY	WORKS

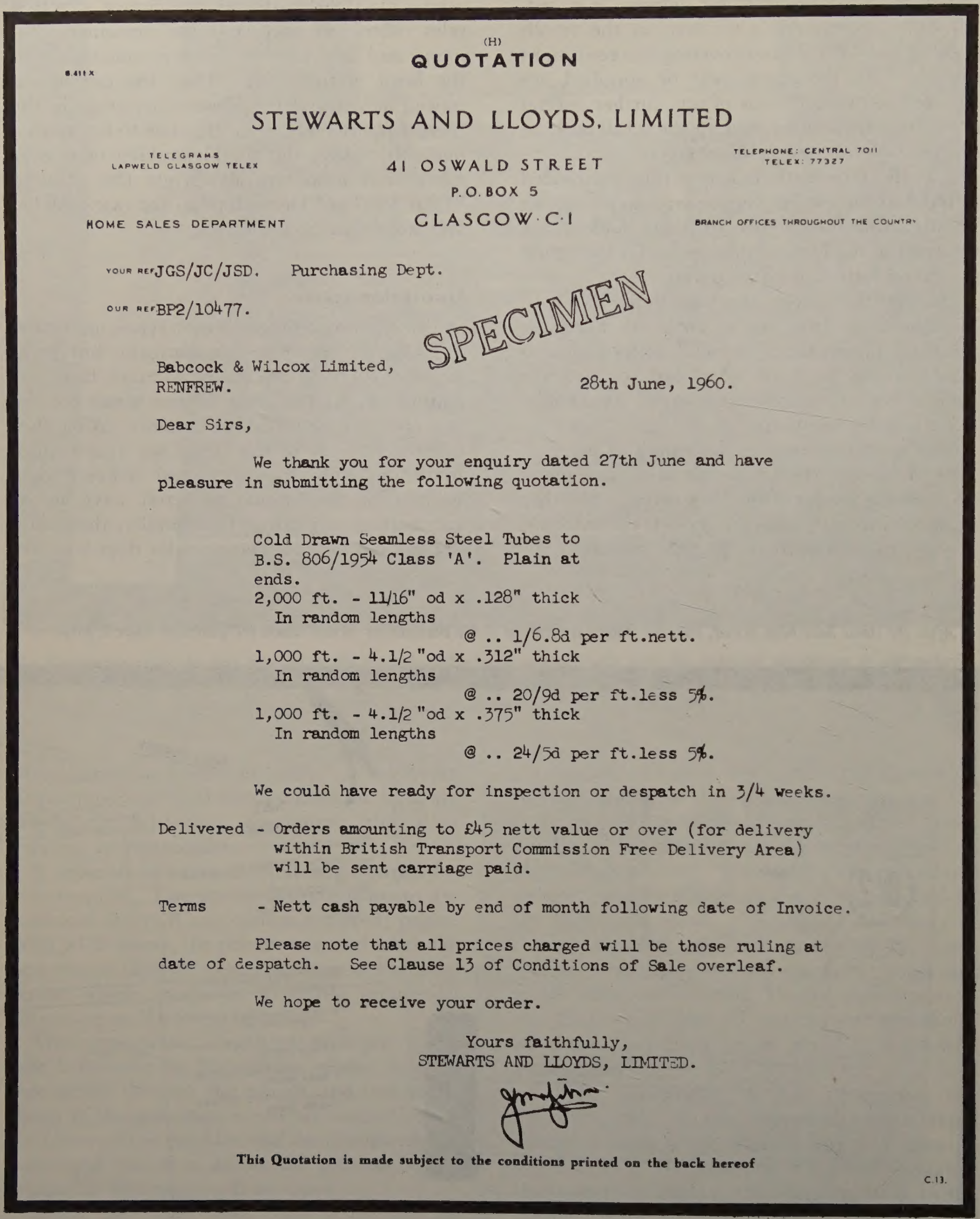
Item No., Description, O/D., Quantity, Thick's., etc.

Prices, Premiums, Extras, etc.

SPECIAL NOTES

STANDARD CLAUSES TO BE USED *

*If not standard state Special Clause Numbers here
or write additional Clauses here



(H)

QUOTATION

8.411 X

STEWARTS AND LLOYDS, LIMITED

TELEGRAMS
LAPWELD GLASGOW TELEX

41 OSWALD STREET
P.O. BOX 5
GLASGOW·C·1

TELEPHONE: CENTRAL 7011
TELEX: 77327

HOME SALES DEPARTMENT

BRANCH OFFICES THROUGHOUT THE COUNTRY

YOUR REF JGS/JC/JSD. Purchasing Dept.

OUR REF BP2/10477.

SPECIMEN

Babcock & Wilcox Limited,
RENFREW.

28th June, 1960.

Dear Sirs,

We thank you for your enquiry dated 27th June and have pleasure in submitting the following quotation.

Cold Drawn Seamless Steel Tubes to
B.S. 806/1954 Class 'A'. Plain at
ends.
2,000 ft. - 11/16" od x .128" thick
In random lengths
@ .. 1/6.8d per ft.nett.
1,000 ft. - 4.1/2 "od x .312" thick
In random lengths
@ .. 20/9d per ft.less 5%.
1,000 ft. - 4.1/2 "od x .375" thick
In random lengths
@ .. 24/5d per ft.less 5%.

We could have ready for inspection or despatch in 3/4 weeks.

Delivered - Orders amounting to £45 nett value or over (for delivery within British Transport Commission Free Delivery Area) will be sent carriage paid.

Terms - Nett cash payable by end of month following date of Invoice.

Please note that all prices charged will be those ruling at date of despatch. See Clause 13 of Conditions of Sale overleaf.

We hope to receive your order.

Yours faithfully,
STEWARTS AND LLOYDS, LIMITED.

This Quotation is made subject to the conditions printed on the back hereof

C.13.

The sales quotation letter. Almost all the information contained in this letter is typed automatically by the Flexowriter at a speed of approximately ten characters a second to select the "red typing" key; this is done automatically for her. After all the items have been typed in sequence on the letter the operator removes the quotation tape from the reader and replaces it with a file tape that contains the standard clauses specifying the conditions under which goods are supplied. Several versions of the "standard clauses" tape are kept to cover different methods of delivery, payment and discount allowed. Lastly, any special clauses are added manually and the quotation letter is complete.

The tape used to produce the quotation is thrown away, the standard clauses tape is returned to the file and the letter is sent to the sales office for signature. Before signing, the clerk checks the data printed in red as these are the only entries likely to contain errors. Afterwards the letters are despatched and the document folders filed away pending receipt of the order from the customer.

Print suppression

Throughout the procedure described, extensive use is made of the print suppression facility provided on Flexowriters. Among the data punched in the customer's master-card set are machine instructions that control the operation of the Flexowriter during the subsequent procedures together with the customer's full address and the phrases that appear in the quotation letter such as "Dear Sir,".

When the enquiry allocation list is prepared only the customer's name and town are printed. In contrast, when the quotation scroll is prepared the full name and address are printed. Similarly the phrase "Dear Sir," although recorded in both paper tapes used to prepare the first two documents, only appears on the final document of the data processing sequence —the quotation letter.

Two special codes are provided in the list of Flexowriter programme instructions to control the selective printing operations. One is a "non-print" code and the other a "print restore" code. Naturally, when the non-print code is read from the tape the printing action is suppressed and remains inactive until the print restore code is read. Although the information recorded in the tape between these codes does not appear in print, if the Flexowriter punch is switched on during this operation the non-print data are punched in the output tape. However, during the changeover from print to non-print the code that initiates this action is not punched in the output tape. This is the only information that is not transferred from the input to the output tape.

To illustrate this point more fully, consider the phrase "Dear Sir,". This phrase is punched in the customer's master-card set preceded by two non-print instructions and is followed by a print restore instruction. During the first procedure—the preparation of the enquiry allocation list—the phrase is read from the master card but is not printed. However, it is punched in the output tape, but the first non-print instruction is not reproduced in this tape. The print restore code is always punched in the output tape following a non-print operation. A similar sequence occurs during the second procedure—the phrase is read from the product tape: it is not printed on the quotation scroll, but is punched in the output tape minus the remaining non-print code.

Now, when the quotation letter is prepared, the phrase is not preceded by any non-print codes as they have all been discarded; consequently in the appropriate position the Flexowriter types "Dear Sir,". In this way, data can be carried forward automatically from one procedure to the next, finally to be printed in the correct position on the correct document.

Flexowriters are versatile machines and a choice of operational features is available. Consequently Flexowriters are, as it were, tailored to suit the particular application and the clerical systems used. The machines supplied to Stewarts and Lloyds cost less than £1,800 each and have increased productivity to the extent that two persons can now perform the work on which formerly five typists were employed. The machines were installed on March 3rd, 1958, and have been in continuous use since then for, at least, 8½ hours each day. No failures, other than minor operational defects, have been encountered during this period.

Eight members of the central typing department have been trained to operate the machines and, as was mentioned earlier, the machines are kept in use throughout the normal office lunch hour. The number of quotations is steadily increasing and a third Flexowriter was installed in August of this year to cope with the additional work.

The two principal advantages obtained from this installation are increased productivity and, more important from the commercial point of view, promptness.

Electronic record-keeping

A machine for the smaller business that can keep track of 5,000 stock records

An inexpensive special purpose machine that employs many of the components and techniques developed for electronic computers has been built by the Electronic Machine Company Limited. Developed specifically for the smaller business, it costs £4,750 in basic form.

Intended primarily for keeping a continuous check of stock totals, the machine up-dates stock records and calculates new totals as goods are received or despatched. At the end of the day a list can be produced showing the current stock position of up to 5,000 items. Also, the machine can be interrogated at any time to discover the current stock position of any particular item

An electronic machine for up-dating and storing 5,000 stock records can now be bought for £4,750. It consists of a magnetic drum, a power supply unit, an electronic control unit, an arithmetic unit and an electric typewriter. Information is stored on the magnetic drum, additions and subtractions are performed by the arithmetic unit and data are entered into the system and results obtained via the electric typewriter. All these operations are initiated in the correct sequence by the control unit.

Designed as a special purpose calculator, this machine* makes use of many of the components and techniques developed for electronic digital computers. The principal object of the design was to create a record-keeping machine of low capital cost, suitable for the smaller business, that nevertheless provides the user with many of the advantages of electronic operation. Among the more important of these latter are the rapidity with which new data can be fed in and the equally prompt answers supplied to requests for information. In addition, records are up-dated quickly and entries and queries can be handled in the random order in which they are received without slowing down the speed of operation.

Stock-keeping is the work for which the machine is primarily intended, although, of course, it would also be suitable for many other jobs of a similar nature. An application for which it has been suggested the machine might prove useful is to record reservations for a theatre or travel agency. Another obvious use is for sales analysis work. However, as store-keeping is likely to be the principal application, the manner in which the machine may be employed on this type of work will be described.

Whenever a transaction is completed, a copy of the relevant document—either the goods inward note or the despatch note—is passed to the machine operator. She then enters on the keyboard of the typewriter the reference number of the transaction note, the stock code number of the item and, finally, the quantity. A + or – key is then selected to indicate whether the goods are being received into store or despatched.

As the operator types the quantity it is entered into the machine and the value is displayed on a set of four decimal neon number tubes. When the + or – key is pressed the numerical value is sent immediately to the arithmetic unit and, simultaneously, the appropriate sign is illuminated on the neon tube display. By examining the number and sign shown, the operator can confirm that she has entered the transaction data correctly.

Next, the operator presses the "enter" key. Immediately, the appropriate stock total is located on the drum and this value is displayed on a second group of four neon number tubes. At the same time, this total is sent to the arithmetic unit, which already contains the transaction

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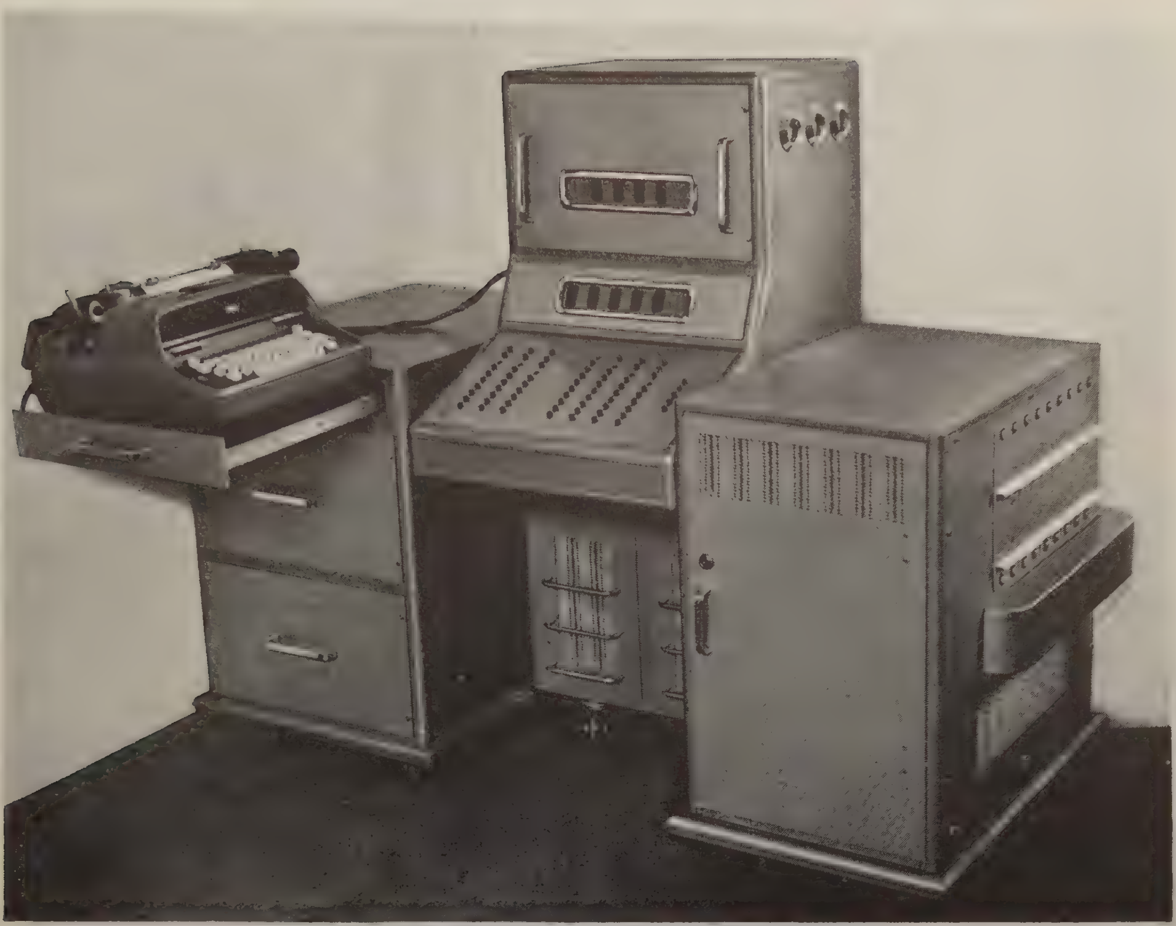
* Designed and built by the Electronic Machine Company Limited, Mayday Road, Thornton Heath, Surrey, Great Britain.



The prototype electronic record-keeping machine is equipped with a 16-inch diameter magnetic drum

data. Here, the two figures are combined and the new up-dated total is transmitted to and recorded in the correct position on the magnetic drum. Simultaneously, the typewriter carriage moves across and the old stock total and the transaction quantity are printed on the form.

In this way a continuous record can be maintained of the stock position of all items held in store and, at the end of the day, the machine can be set to print out automatically a list of all item reference numbers and the corresponding stock totals.

The prototype machine may be operated in this manner, but, of course, many other versions can be built. For instance, a push-button keyboard can be provided in place of the typewriter.

Data are displayed on two groups of neon number tubes

Actually, the prototype is equipped with both a typewriter and a push-button keyboard. Three sets of buttons are provided. The stock code number is selected on one set, the quantity is entered on the second set and the operation of the machine is controlled by the third. A machine equipped with a push-button panel need not necessarily be equipped with an electric typewriter, because all the necessary information can be read from the neon number tubes. Alternatively, the typewriter can be used solely as an output printer, all data being entered on the push buttons. Also, in those cases where a typewriter is fitted, arrangements can be made for it to be operated independently of the remainder of the machine. Thus the narrative sections of a commercial document can be typed manually.

Finally, the particular items of data displayed on the neon tubes can be changed. In the application just described the original stock total is displayed before it is up-dated. If required, the revised total after the transaction quantity has been added or subtracted may be displayed instead.

Another feature that can be added to the machine is a circuit which indicates whether the new stock total has fallen below a specified level. Immediately the new total has been obtained it is compared with a re-order control total stored on the magnetic drum. If the new total is less than the control total, the new total is printed in red, conversely, if greater, it is printed in black. Thus, the operator can easily see which items are in short supply.

The magnetic drum fitted to the basic machine can accommodate 5,000 records—each of four decimal digits. Larger magnetic drums can be provided to hold either more or longer records. For instance, where automatic facilities for indicating when stock totals have fallen below specified re-order levels, additional storage capacity has to be provided in each item record for at least two or three more decimal digits.

An IBM electric typewriter can be fitted and used as a data input-output unit. It is also possible to operate the typewriter independently of the machine

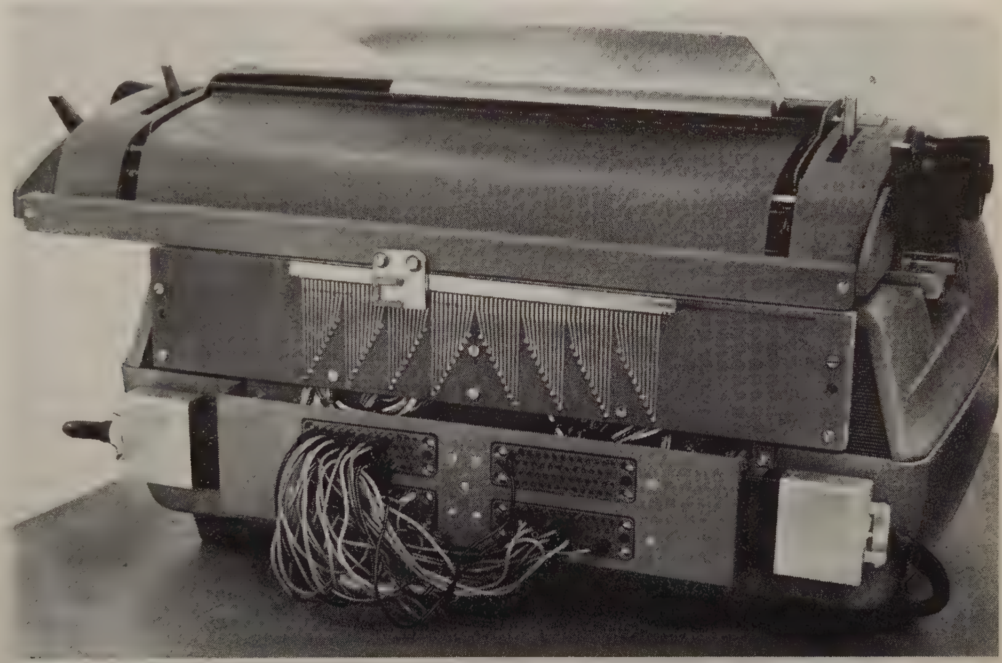
The most convenient way of increasing information storage capacity is to fit additional drums of the standard pattern which means that the capacity is increased in multiples of 5,000 four decimal digits. Information is recorded on the drum, which is 16 inches diameter, in decimal form. Forty four recording tracks are provided. Forty are used for data, the remaining four being for control purposes. Five hundred addresses or stock item record positions are provided round the circumference of the drum and the 40 recording tracks are divided into ten groups of four to give the 5,000 record positions quoted for the standard drum. However, as mentioned earlier, the arrangement of the data on the drum can be adjusted to suit the particular application. For instance, instead of 5,000 four-digit records, 2,500 eight-digit records could be handled.

When a stock total is up-dated, the old total is read from the drum and sent to the arithmetic unit, where it is modified and the new total is written back on the magnetic drum in exactly the same place from which the old total was obtained. The act of writing the new information on the drum automatically erases the old. An item record can be located on the drum, read from it and transmitted to the accumulator in one second.

Recording stock limits

Stock re-order totals are recorded on the drum semi-permanently. This means that the operator cannot change these numbers either accidentally or deliberately. However, a push-button control panel is provided within the machine so that this information can be altered whenever this is necessary.

An IBM typewriter is fitted to the prototype machine as a data input-output unit. When information is being typed on the keyboard, those items to be transmitted to the machine are selected by a printed circuit and a plugboard assembly attached to the back of the typewriter. This selector assembly ensures that, whenever the carriage is in the correct position, data entered on the number keys are transmitted directly to the machine. If a different job is to be performed, it is a simple matter to change the arrangement of the connections on the plugboard.



The printed-circuit selector fitted to the IBM typewriter. As the carriage moves, the electric sliding contact connects the typewriter with the appropriate control circuit

All the equipment—the magnetic drum, power supplies, arithmetic unit and associated electronic circuits—are contained in a console that is not much larger than an office desk. Electric power requirements are modest—the equipment can be operated from a standard 13-ampere 230-volt supply.

In its present form the machine provides simple, rapid up-dating and recording facilities at low capital cost. Future developments include the provision of punched-paper tape and punched-card data input-output units in order that the machine may be used in conjunction with existing data processing installations.

Machine reading

A survey of the printed codes that can be read directly by both men and machines and of the reading machines developed

Manual transcription of data from the commercial documents in everyday use on to documents that machines can read, such as punched cards, is a redundant, time-consuming operation. Several codes which can be read instantly by both men and machines have been designed to overcome this problem and those printed in magnetic ink have reached an advanced stage of development. In fact, the E-13B code has been adopted by the American Bankers Association as the common language for use on all cheques and deposit slips in the U.S.A. And soon, the British banks are expected to announce their choice. The three codes under consideration—E-13B, Fred and C.M.B.—are described in this article together with the reading machines developed to handle information in this form. In addition, an account is given of the technique of reading print optically and of research into methods for reading handwritten data

As all are aware, one of the great problems in data processing is how to transcribe the basic data—quickly and efficiently—into a code that can be read by a machine. At present, of course, the majority of this work is performed manually and, if errors are to be avoided, a considerable amount of effort must be expended in checking the accuracy of the transcribed information before it is supplied to the computer—work that contributes nothing to the data processing procedure and, indeed, delays it.

Console of Solartron Era optical reading machine

The first and most obvious approach to the problem was to develop machines that read print optically. However, it was soon discovered that the electronic circuits needed in order to be able to read the more common styles of type were so extensive that if a machine was to be produced at a reasonable cost, reading would have to be restricted to one type fount. And, as was to be expected, overprinting, random marks and creases in the paper caused by handling made the task of machine reading infinitely more difficult. Consequently, progress in optical reading has not been as rapid as originally anticipated. Nevertheless, two companies—the Intelligent Machines Research Division of the Farrington Manufacturing Company in the U.S.A. and the Solartron Electronic Group in Great Britain—have both developed optical readers. Articles describing these machines have already been published in *Data Processing*.*

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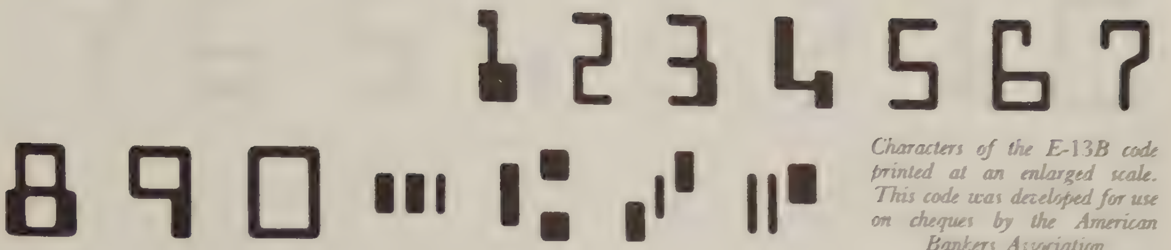
*See "Automatic reading," *Data Processing*, January-March, 1959, and "Reading machines," *Data Processing*, July-September, 1960.


Characters of the E-13B code printed at an enlarged scale. This code was developed for use on cheques by the American Bankers Association

Briefly, an optical reading sequence is performed as follows:—A spot of light is made to scan each part of the area containing the printed character. Light reflected from the surface of the paper is collected and projected through an optical system on to a photomultiplier (a very sensitive photo-electric cell) that produces an electric signal, the strength of which depends upon the intensity of the reflected light. The electric signal produced as the spot of light scans the area containing the letter (or figure) naturally varies according to the shape of character being read. The signal is then sent to an electronic circuit, called a logic circuit, which recognizes the general shape of the waveform and so identifies the character.

The logic circuit has to be designed so that it can correctly identify signals derived from imperfect or mutilated characters and discard spurious signals resulting from, say, a smudge or dirt. As a result, the circuits tend to be complicated and expensive.

In Great Britain Solartron Eras (Electronic Reading Automatons) have been ordered by the following firms: Boots Pure Drug Company Limited, Domestic Electric Rentals Limited and Montague Burton Limited. All three machines are designed to read information from tally rolls at a speed of between 200 and 300 characters a second.

In the U.S.A. 27 readers built by the Intelligent Machines Research Division are in operation and a machine that reads 200 characters a second from a normal typewritten page has recently been delivered to the United States Air Force Air Research and Development Command. An experimental machine to read addresses printed on envelopes is also under development for the United States Post Office.

Another optical reader, one that reads data from cash register tally rolls, is manufactured by the Swedish company Svenska Dataregister AB. This machine,† however, reads a special printed bar-code which, although not immediately legible to human operators, can be learnt. A bar-code was chosen because this simplifies the task of machine reading.

About the time that the first optical readers were being built, the American Bankers Association (A.B.A.) were investigating methods of recording data on cheques in such a way that the information could be read both visually and mechanically. And in July, 1956, the A.B.A. announced its recommendation that the most suitable method of recording such information would be by printing characters in magnetic ink.

To the human eye, characters printed in magnetic ink are identical with those printed in ordinary ink, but, because a magnetic material in powder form is mixed in with the ink, a reading machine senses the shape of the printed outline magnetically instead of optically.

Undoubtedly, the reasons that influenced the A.B.A. in their choice were that cheques receive a considerable amount of handling and often are overstamped or written on. All these actions, of course, seriously affect optical reading. However, as long as the overstamped impression contains no magnetic material, and this is extremely unlikely, the magnetically printed characters remain perfectly legible to a magnetic-reading head although visually they may appear to be obliterated. Also, at that time, it was probably thought that magnetic reading was easier to accomplish, would be more accurate and the time required to develop the necessary code would be reasonably short.

E-13B code

Soon after the A.B.A. decision was announced, all the major business machine manufacturers and printers in the U.S.A. agreed with the recommendation and co-operated in the design of a suitable range of characters. And in December, 1958, agreement was reached on the final form of these characters and the new code

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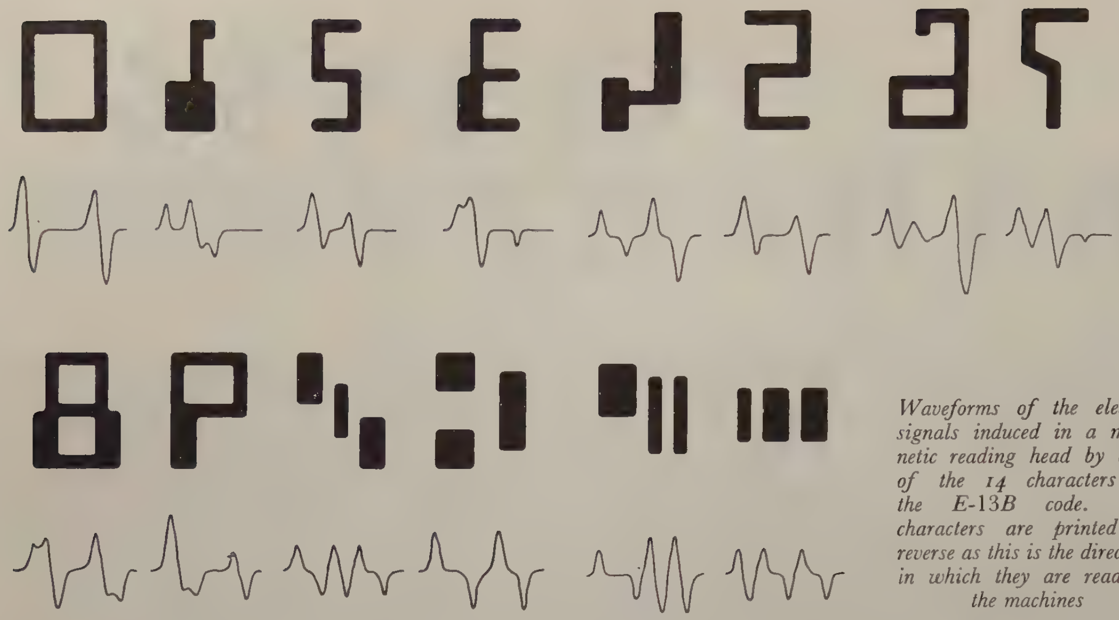
†Described in "Recording data at the point of sale." *Data Processing*, January-March, 1960.



Waveforms of the electric signals induced in a magnetic reading head by each of the 14 characters of the E-13B code. The characters are printed in reverse as this is the direction in which they are read by the machines

known as E-13B was announced. It consists of 14 characters—the ten decimal digits 0 to 9 and four control symbols.

As can be seen from the illustration, the outline of individual figures has been accentuated. This was done to make the figures as different from each other as possible so that, when they were read by machine, there would be no chance that a poorly printed figure would be incorrectly recognized. Machine recognition has to be prompt and positive. If any doubt exists, the document must be rejected automatically.

The figures in the illustration are reproduced at an enlarged scale; normally the printed characters are $\frac{1}{8}$ inch high (9-point in the printer's "vocabulary").

Before E-13B characters can be read, they have first to be magnetized and this is done by passing the document beneath a powerful electromagnet. Next the document is transported, from left to right, past a magnetic reading head at a constant speed. This induces an electric current in the reading circuit, the voltage of which is proportional to the rate of change of magnetic flux. That is to say, the strength of the signal induced is proportional to the rate of change in the quantity of magnetic ink passing beneath the reading head.

Each character in the code produces a signal waveform of a distinctive shape. Examples of the waveforms generated are shown above. The decoding circuits attached to the reading head identify these waveforms and, in this way, the characters are recognized.

In one reading system the waveform generated is retained in a nickel delay-line store and the value of the signal at eight equi-spaced points is sampled and supplied to fourteen logic circuits—one logic circuit for each of the characters in the code. A strong output signal will be emitted by the logic circuit corresponding with the particular character read. If two or more output signals of comparable strength are generated, identification is not positive and the character is rejected as unreadable. In this way, reading accuracy is assured and the risk of an error being made is slight.

Although the E-13B code was developed as the common language for the banking profession in the U.S.A., agreement had to be sought on many other points before the code could be used. For instance, agreement had to be reached on what information was to appear on a cheque, where it was to be printed and the sequence in which it was to be arranged.

The standards adopted are these:—The E-13B characters are printed in one code line across the bottom of the cheque $\frac{1}{4}$ inch above the lower edge. A clear band $\frac{5}{8}$ inch wide is maintained across the bottom of the cheque and the code line is printed within this area. Any other designs appearing in this "clear area" must be printed in non-magnetic ink.

On American cheques the code line is divided into four sections. In two of these sections the bank that issues the cheque can print whatever information it requires for its own purposes. Such information can be the cheque serial number, customer account number, type of account and so on. In the remaining two sections only specified information may be printed. For example, in the section on the extreme right of the code line are printed ten figures which indicate the amount for which the cheque is drawn. To the left, in the next section but one, are printed two groups of four digits separated by one of the printed control symbols. This is the transit number—that is the bank and branch reference number (four digits each).

A suggested arrangement of similar data on a British cheque is shown in the illustration. In this case eleven digits are allocated for the amount and six for the bank and branch number. The cheque serial number and the bank and branch number are printed twice, once in the E-13B code in the code line and, again, at the top of the cheque. The customer's name is also printed on the cheque.

With an automatic accounting system it is necessary to print the customer's account number on every cheque and, since the cheques are "personalized" in this way, the customer's name is added in order to prevent the cheque being issued inadvertently to the wrong person. Most of the United States business machine manufacturers have built equipment to handle cheques on which data are printed in the E-13B code. Naturally the first type of machine developed was a sorter-reader, since document sorting is one of the most time-consuming jobs bank staff have to perform. As the name implies, a sorter-reader reads numerical data from a cheque and then directs the cheque into the appropriate one of a number of pockets. This procedure is identical with that used when sorting punched cards.

Sorter-readers

In March of this year, Burroughs demonstrated one of these machines‡ in Great Britain and during the summer it was shown on the continent of Europe. It sorts cheques at the rate of 1,560 a minute.

The National Cash Register Company, in conjunction with Pitney-Bowes Incorporated, have also developed a sorter-reader. This machine handles documents at the rate of 750 a minute. A Pitney-Bowes National

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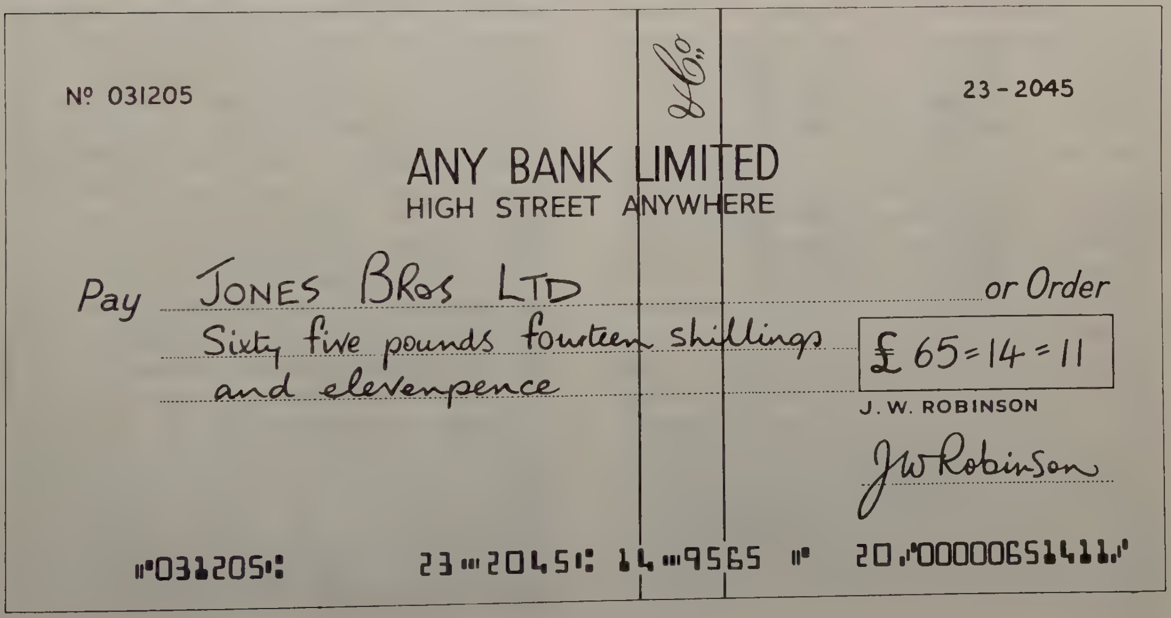
‡ This machine and other items of equipment developed for banking work by Burroughs are described in the article "Automatic banking," *Data Processing*, July-September, 1960.

E-13B characters printed in a code line across the bottom of a specimen British cheque



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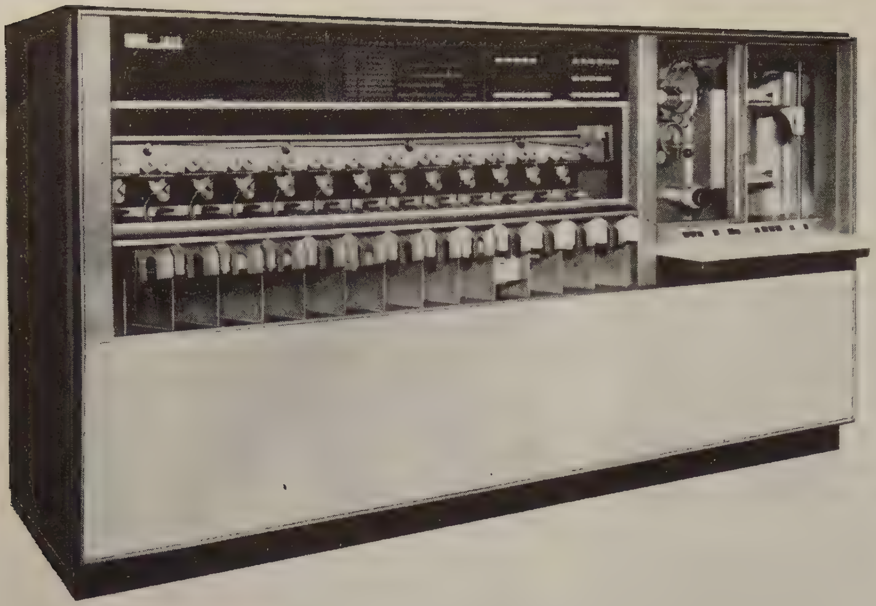


Cheques and deposit slips are sorted at speeds of up to 950 *a minute by the IBM* 1210 *sorter-reader*

sorter-reader, installed at the National Newark and Essex Bank, New Jersey, U.S.A., is reported to have sorted already well over five million cheques without a mistake. Previously the bank spent 40,000 man-hours every year on hand-sorting cheques. Now the time required for this job is expected to be reduced by as much as 95 per cent.

IBM 1210

IBM also manufacture a range of machines to operate with the E-13B code. These have been given series model numbers ranging from 1200 upward. The IBM 1210 is a sorter-reader that handles 950 documents a minute and is equipped with 13 pockets (ten pockets numbered from 0 to 9, a reject pocket and two special pockets labelled A and B). Six digits, in addition to the one being used for the sorting operation, can be read from each document as it passes through the machine. A device for checking account numbers and confirming that they are valid can also be provided. Batches of documents of mixed sizes may be sorted, provided they are within the limits 6 inches by 2¾ inches and 8¾ inches by 4 inches.

In addition to the sorter-reader, IBM manufacture a machine known as the 1201 proof inscriber. This is used for printing the amount and other data in the E-13B magnetic characters in the appropriate positions of the code line on both cheques and deposit slips.

Once the sorter-reader had been developed, it was a relatively easy matter to connect this machine by cable to other data processing equipment. Sorter-listers provide one such assembly. As the cheques are read and sorted, the information obtained is printed on a list. Another obvious application is to connect a sorter-reader to a computer so that information read from cheques is fed directly into the computer store and used at once to up-date the customers' accounts.

The Fifth Third Union Trust Company, Cincinnati, Ohio, U.S.A., propose to operate such a system. Two Pitney-Bowes National sorter-readers will handle documents printed in the E-13B code at a rate of 750 a minute each. From these machines the information will be sent directly to a National Cash 304 computer equipped with six magnetic-tape units. Records of the Bank's 70,000 accounts are to be kept on magnetic tape and the information supplied by the sorter-readers will be used to up-date these accounts. In addition, the computer will produce statements, daily records of transactions and other management reports, as required. The installation is scheduled to be completed and running by January, 1961.

The size of the task to be performed by this data processing system can be gauged from the fact that at present the bank handles daily 120,000 of its own cheques and deposit slips and up to 150,000 items belonging to other banks.

Another computer making use of a sorter-reader as a data-input device is the Visible Record Computer (B251) built by Burroughs.

The IBM 1210 can also be connected to various data processing machines by means of a unit known as the IBM 1221 sorter-reader control. Machine systems to which this equipment may be connected directly or via a magnetic tape unit are the IBM 407 accounting machine and the IBM 650, 705, 7070, 1401 and 305 Ramac computers.

From this description of the development and application of the E-13B code it will be appreciated that the code is already well established in the U.S.A. and is rapidly being brought into use by the American banks as a true common language code.

Fred code

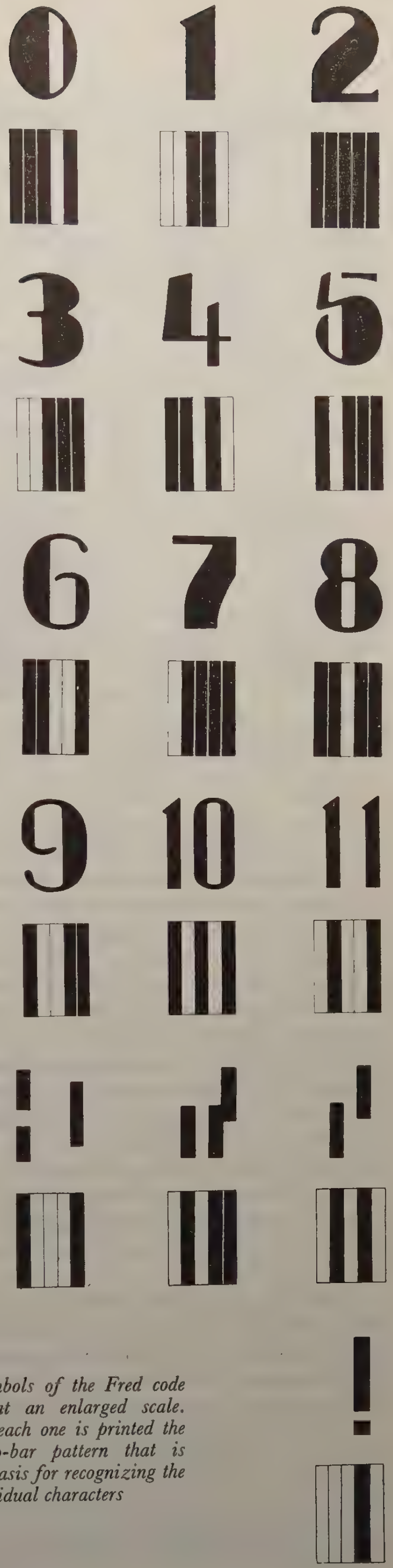
A machine reading system known as Fred (Figure Reading Electronic Device) has been developed in Great Britain by E.M.I. Electronics Limited. In common with other systems of this sort, a special design of type fount is read.

A range of 16 characters can be identified—the ten decimal digits 0 to 9, plus six control symbols. If the two digits of the sterling values 10 and 11 are printed close together they may be handled and read as single characters, in which case four symbols remain available for control purposes.

As can be seen from the illustration on the right, all the characters of the Fred code are easily recognized, but, as mentioned earlier, the shape of the figures has been modified to make the task of identification by machines easier, thereby reducing the risk of ambiguity.

Fred numerals can be read either optically or magnetically. At present, because of the great interest shown by the European banks, development work is being concentrated on perfecting the reading of magnetic characters, although the prototype Fred reader, built in 1958, was an optical machine. The principle of operation is the same, whichever method of reading is used, but because the optical technique is somewhat easier to understand this procedure will be described first.

The printed characters are read one at a time and the outline of each is scanned from right to left. With the optical reader, the document bearing the line of printed figures is drawn past a narrow viewing slit at a closely controlled speed. Consequently only a small vertical section of a character can be seen through the slit at any instant. A light shines from above on to the portion of the paper framed by the slit and the light reflected from the surface is directed into a photomultiplier. The strength of the signal produced by the photomultiplier is proportional to the intensity of the reflected light. Naturally, a signal of



The 16 symbols of the Fred code reproduced at an enlarged scale. Underneath each one is printed the equivalent 5-bar pattern that is used as the basis for recognizing the individual characters maximum strength is produced when the paper exposed to view is completely white and a signal of minimum strength is generated when the paper is completely black.

A character is recognized by sampling the strength of the electric signal at five positions; in effect, this means that the character is identified by splitting it into five vertical sections or bars.

Fred numerals were developed from a type fount called Broadway, the basic shape of each figure being modified so that every one of the five bars into which it is divided is, as nearly as possible, either completely black or completely white. Obviously, because a legible outline had to be preserved, this condition could not be achieved completely, but by careful design it was possible to make the bars either predominantly black or predominantly white. Thus the strength of the signal produced by the photomultiplier at any instant is either near the maximum or near the minimum signal level, never at any ambiguous intermediate value.

When this signal is sampled, if the strength is near the minimum level the corresponding bar of the character is regarded as black (represented by a pulse—binary 1[§]) and if near the maximum the corresponding bar is taken to be white (represented by no pulse—binary 0). In this manner the continuous electric signal is converted into an equivalent binary pulse code that can be recognized automatically by electronic logic circuits.

The complete sequence for reading a character is as follows:—Before the first printed character reaches the viewing slit only white paper is exposed (maximum signal strength) and during this phase the reading circuits remain inoperative. As soon as the right-hand edge of the first figure appears in the slit the area exposed to view becomes progressively darker until a control circuit recognizes it as being predominantly black. Immediately the reading circuits are triggered and the reading cycle begins.

A synchronizing unit samples the strength of the signal at four fixed time intervals and, in effect, causes the machine to examine the four bars immediately following the first black bar that triggered the reading action. Thus a four-bit code group is obtained and from this the logic circuits identify the figure that has been read. Since each figure is identified by a four-bit code, the number of unique combinations possible is 2^4 or 16. The binary code for each of the 16 characters of the Fred code is shown in the table above. Five bits are shown for each character because, as already explained, the first bit in each group is the 1 or "black bar" which triggers the reading action. It will be noted that characters are scanned from right to left: in the table the bits are shown in the sequence in which they are obtained by the reading circuit.

FRED CODE
reading from right to left across character

0	10111
1	11000
2	11111
3	11100
4	10110
5	11101
6	10011
7	11110
8	11011
9	11001
10	10101
11	10010
Control symbol	10001
Control symbol	11010
Control symbol	10100
Control symbol	10000

From the description just given, it will be realized that the thin horizontal strokes used in some of the figures do not contribute anything to the machine reading sequence. These lines are included solely to make the figures legible to human readers. As far as the machines are concerned, each character is read as a plain 5-bar code.

Characters for optical reading are printed in ordinary ink. If, however, these same characters are printed in magnetic ink the figures can be read in a similar fashion by a magnetic head instead of an optical head. A small magnetic head, of the same shape as the viewing slit, replaces the photomultiplier assembly and as each character is transported past the reading head an electric signal of varying strength is induced in the reading circuit. And, also as before, this signal is sampled and transformed into a four-bit code which is identified by the logic circuits.

This then is how the simpler versions of the Fred readers, both optical and magnetic, work. But where accuracy is of supreme importance, and banking is one of these, a new reader has been developed that operates in a fashion similar to those already described except that it can read and correctly identify badly printed or mutilated figures which would be beyond the capabilities of the simpler readers.

[§] For an explanation of binary codes, see "The universal language of computing," *Data Processing*, January-March, 1959.

Each figure is read as a sequence of five vertical bars, only this time, instead of the columns being spanned by one reading head, a number of separate smaller heads are grouped in a line close together to make a multiple head. A different method of identifying black and white bars is also employed. The rule is that if the areas beneath any two adjacent heads are recognized as being black, then the entire column is considered to be black. This is because only in a black column are the printed areas sufficiently large to cover two adjacent reading heads.

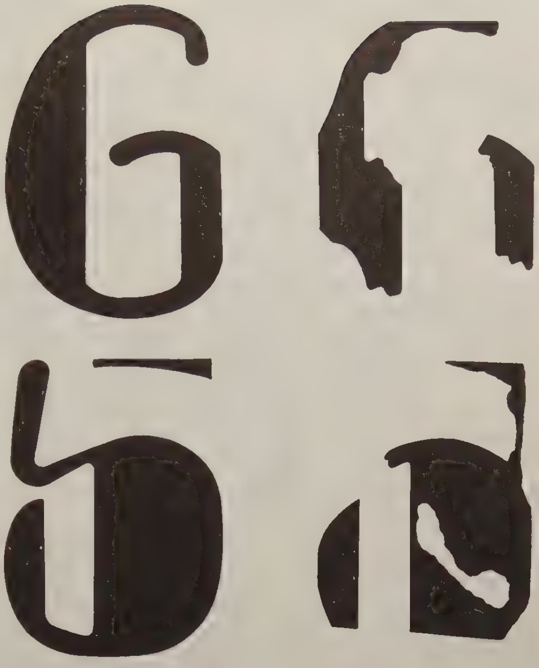
All other patterns detected by the reading heads belong to columns that are white. Thus, if the signals received from two or three heads indicate that the latter are over black areas of the character but no two of these heads are adjacent, then the column is considered to be white.

The size of the individual heads in a multiple reader and the space between them is such that the thin horizontal strokes used in a figure cannot, in any circumstances, produce a signal in two adjacent heads.

The great advantage of this method of reading is that the quality of the printed character can deteriorate to a remarkable extent before the reading circuits are unable to identify the character.

Examples of malformed characters that can still be correctly identified are shown. Both these figures are probably illegible to human readers but they would be correctly identified by a Fred multiple-head reader. Naturally, figures as poorly printed as those illustrated would never be accepted by a commercial firm, but this degree of latitude ensures that there will be no doubt or difficulty in identifying properly printed figures.

Another of the major advantages claimed for the Fred code is that generous printing tolerances can be allowed. This is because the reading head overlaps the figures, top and bottom; consequently the position of the code line printed on the document does not have to be controlled within narrow limits. For example, in the case of cheques, the distance of the code line from the lower edge of the paper can vary by plus or minus $\frac{1}{16}$ inch—more if need be.



On the right are shown mutilated versions of the figures 5 *and* 6 *that can still be identified by a Fred multiple-head reader*

Also, when a multiple-head reader is used, the magnitude of the signal induced in the reading circuits is not critical provided that it is of sufficient strength to be identified. This means that the quality of the magnetic ink can vary within a fairly wide margin.

Finally, the reading cycle is initiated by each character in turn; consequently, the lateral spacing of the characters in the code line does not have to be precise. Also the absence of ink (voids, as they are called) within the outline of the printed characters of up to 0·01 inch in diameter can be accepted.

As a result of these wide operational tolerances, no special printing facilities or equipment are needed. Indeed, mixed batches of documents on which Fred characters have been printed by both litho and letterpress have been handled successfully. In addition, no difficulty has been experienced in identifying Fred figures printed from embossed address plates or by impact printers where the impression is obtained from an inked ribbon. The Monotype Corporation has developed the necessary type matrixes for the Fred code.

Fred readers, both optical and magnetic, may be connected to most forms of data processing equipment. One version of the reader under development will be able to feed information to an Emidec 1100 computer. Fred readers could also be connected to electric listing and totalling machines.

Recently the first machine operating with a Fred magnetic character reader was demonstrated. It was a Pitney-Bowes National sorter. Mixed batches of cheques, ranging in size between 6 by 3 inches and 8 by 4 inches and of varying thicknesses, are sorted at the rate of 750 a minute. Along the bottom of each cheque, $\frac{1}{4}$ inch from the lower edge, is printed the line of Fred characters. Arranged from left to right along the line are the following items of information: cheque serial number (six digits), bank and branch number (six digits—two digits identify the bank and four the branch), account number (eight digits), transaction code (two digits) and, finally, the amount (maximum of 11 digits).

The sorter demonstrated had 12 pockets—ten numbered from 0 to 9, a reject pocket and a special pocket. Larger machines can be built containing 20 or more pockets. The actual number provided will naturally depend upon the application.

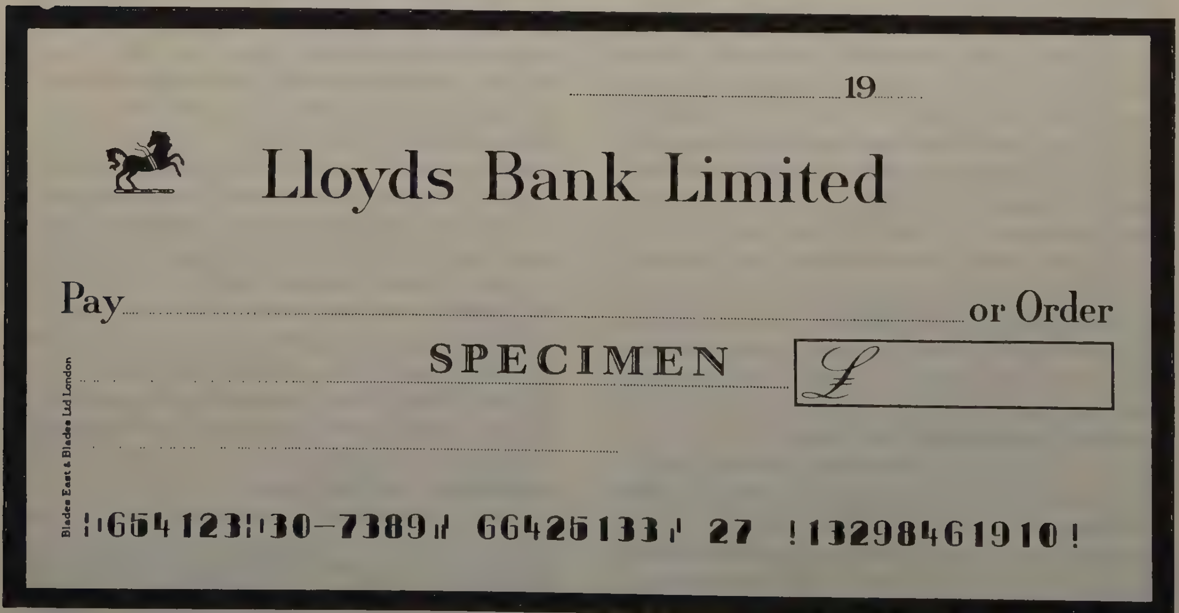
Normally, sorting is performed on one digit at a time; therefore when cheques require to be arranged in branch number order since this is a 4-digit number they have to pass through the machine four times. However, if a large proportion of a particular batch of cheques is known to belong to one branch, these can be directed into the special pocket during the first sorting run. To do this, the 4-digit number of the branch is set on four rotary dials on the control panel of the machine. Then, when the cheques are sorted, all those bearing the selected number are sent to the special pocket, the remainder being sorted into the other pockets in the usual way.

The numbers of documents sorted into each pocket are indicated on a line of electric counters situated below the control panel of the machine. An additional counter is provided to record the total number of documents that are handled.

Another sorter-reader to operate with the Fred code is being designed by the Parnall Company in Great Britain. Provision is being made for this machine to be supplied with any number of pockets within the range six to 50, and it is intended to handle documents at the rate of 1,000 or more a minute.

The speed of operation of sorter-readers is limited by the rate at which the documents can be transported and directed into the various pockets. It is estimated that the character sensing head of a Fred reader is capable of operating at a speed of 10,000 characters a second if required. When cheques are sorted at a speed of 1,000 a minute, the average reading rate is 550 characters a second.

Fred characters printed on a cheque



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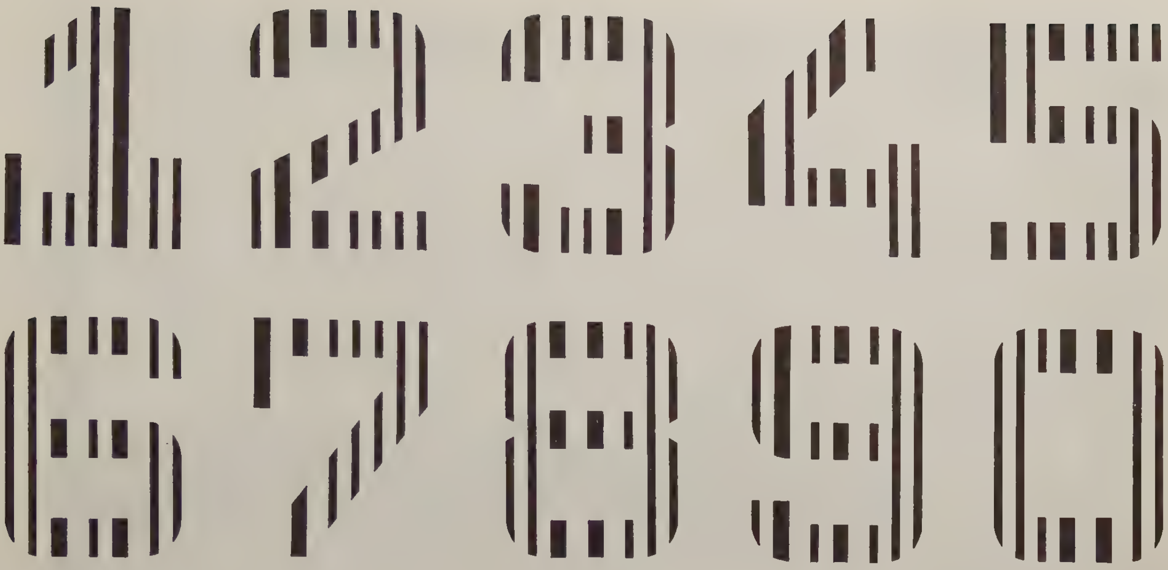


Magnified examples of the C.M.B. characters showing the construction based on seven vertical strokes

C.M.B. code

Unlike the others, the magnetic code developed by the Compagnie des Machines Bull (the French half of the Anglo-French company De La Rue Bull Machines Limited) does not rely upon the characters being of a special shape. Each character is formed by printing a sequence of seven vertical strokes and the outline of the character results from making these strokes of differing lengths. Incidentally, this code is referred to by the initials of the French phrase that describes the stroke system upon which it is based—*caractère magnétique en bâttonnets*—the C.M.B. code.

These strokes or lines are spaced either 0·2 mm or 0·4 mm apart and, when viewed from a normal reading distance the outline formed by them appears to be that of a conventional printed character. The striped appearance which is obvious on close examination does not impair the legibility of the characters because the thickness of the strokes is proportional to the spaces separating them; hence, to the eye the tonal density of the image is uniform. Two of the six spaces formed by the seven strokes are wide (0·4 mm), the remaining four are narrow (0·2 mm), and the particular character is identified by the sequence in which these wide and narrow spaces are arranged.

	Bull C.M.B. code					
1	–	·	·	·	–	·
2	·	–	–	·	·	·
3	·	–	·	·	–	·
4	–	·	·	–	·	·
5	–	·	–	·	·	·
6	·	·	–	·	–	·
7	–	–	·	·	·	·
8	·	·	–	–	·	·
9	·	–	·	–	·	·
0	·	·	·	–	–	·
Control code	–	·	·	·	·	–
Control code	·	–	·	·	·	–
Control code	·	·	–	·	·	–
Control code	·	·	·	–	·	–
Control code	·	·	·	·	–	–

· represents a short interval (count between 20 and 30)
– represents a long interval (count between 36 and 46)

Fifteen characters can be represented by this code—the ten numerals 0 to 9 plus five control signs. A table of the code is given above and printed examples (at an enlarged scale) of the ten decimal digits and one of the control signs are shown in the accompanying illustration. The nominal height of the printed characters is $\frac{1}{8}$ inch.

One of the great advantages of this code is that the shape of the printed characters is conventional and therefore the figures can be read instantly by the human eye. It is also claimed that printing tolerances are wide and that the amount of magnetic ink deposited on each stroke is not critical. Furthermore, the characters can still be read after the document has been severely crumpled and mutilated. It is also stated that the electronic reading circuits are simple to construct.

The characters can be printed by any of the accepted printing processes and also by typewriters and the embossed metal or plastic plates used in addressing machines.

Another advantage of this code is that the shape of the character is immaterial, provided that it is represented by seven vertical strokes. Consequently, when necessary, it will be easy to extend the code to include the alphabet. At present, with the stipulation that two of the six spaces in each character shall be wide, a maximum of 15 characters can be portrayed. However, if the full number of permutations available with six wide or narrow spaces is utilized, as many as 64 characters can be represented.

Reading sequence

C.M.B. characters are read from left to right. As each vertical stroke of a figure passes under the magnetic head, two electrical pulses are generated in the reading circuit—a positive pulse by the leading edge of the stroke and a negative pulse by the trailing edge. Only positive pulses are utilized in the reading sequence; negative pulses are ignored.

To distinguish one character from another, the distances between the leading edges of the seven strokes have to be measured. This is done by moving the document under the reading head at a closely controlled speed and measuring the time intervals between consecutive positive pulses.

The timing circuit consists of an electronic counter which is fed with clock pulses at a constant frequency. Every clock pulse increases the total in the counter by one until a positive pulse is received from the reading circuit. When this occurs, the total in the counter is sent to a decoding unit and the counter is reset to zero. The counting procedure is then repeated—a total builds up in the counter until the next positive pulse is received from the reading circuit.

The number transmitted from the counter to the decoding unit represents the interval that elapsed between the receipt of two positive pulses from the reading circuit. The numerical values obtained in this way are compared with limits set in the machine to determine which of three types of interval has been read.

Measuring intervals

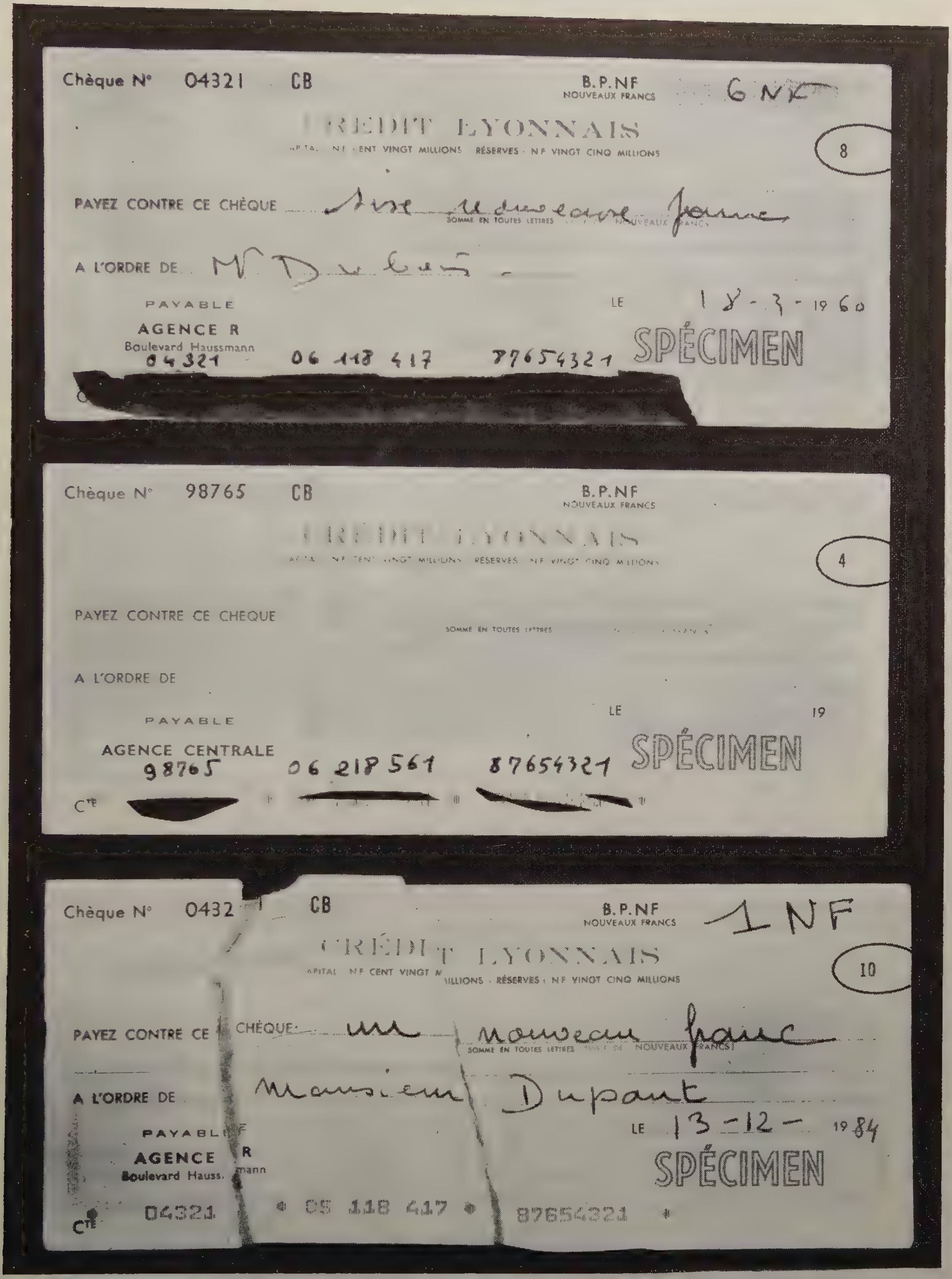
A count between 20 and 30 represents a short interval, between 36 and 46 a long interval, and over 60 a very long interval. Very long intervals only occur between printed characters and, as no upper limit has been set, the characters may be spaced any distance apart. After the type of interval has been determined, this information is sent to and held in one section of a six-position information store.

Thus a reading sequence proceeds as follows: As the first vertical stroke of a character passes under the reading head the counter is set to zero, then the intervals between the leading edges of the six succeeding lines are identified as being either long or short and this information is sent to and held in the six separate positions of the information store. A very long interval is then signalled while the next character approaches the reading head. This very long interval triggers the character-recognition circuit; the data held in store are sent to a character identification unit, leaving the information store free to accept data from the next character to be read.

Three checks are performed during the reading sequence to confirm that the information obtained corresponds to an actual character. A very long interval must appear once in every seven; no interval count should be less than 20, or between 30 and 36, or between 46 and 60; and the information held in the six positions of the information store when the character-recognition circuit is triggered must contain two long intervals.

If the information obtained from a character fails to satisfy these three conditions, the document on which it is printed is rejected automatically.

Since the whole reading sequence depends upon the generation of positive pulses and the measuring of the time intervals between them,



Chèque N° 04321 CB

B.P.NF
NOUVEAUX FRANCS 6 NF

REDIT LYONNAIS
NF ENT VINGT MILLIONS RÉSERVES · NF VINGT CINQ MILLIONS

8

PAYEZ CONTRE CE CHÈQUE Six nouveaux francs
SOMME EN TOUTES LETTRES NOUVEAUX FRANCS

A L'ORDRE DE Mr Dubois

PAYABLE
AGENCE R
Boulevard Haussmann LE 18-3-1960

04321 06 118 417 87654321 SPÉCIMEN

C [illegible]

Chèque N° 98765 CB

B.P.NF
NOUVEAUX FRANCS

CRÉDIT LYONNAIS
NF CENT VINGT MILLIONS RÉSERVES NF VINGT CINQ MILLIONS

4

PAYEZ CONTRE CE CHEQUE
SOMME EN TOUTES LETTRES

A L'ORDRE DE

PAYABLE LE 19
AGENCE CENTRALE

98765 06 218 561 87654321 SPÉCIMEN

C^TE [illegible]

Chèque N° 04321 CB

B.P.NF
NOUVEAUX FRANCS 1 NF

CRÉDIT LYONNAIS
CAPITAL NF CENT VINGT MILLIONS · RÉSERVES · NF VINGT CINQ MILLIONS

10

PAYEZ CONTRE CE CHÈQUE un nouveau franc
SOMME EN TOUTES LETTRES NOUVEAUX FRANCS

A L'ORDRE DE Monsieur Dupont

PAYABLE LE 13-12-1984
AGENCE R
Boulevard Haussmann SPÉCIMEN

C^TE 04321 ⑈ 06 118 417 ⑈ 87654321 ⑈

Examples of severely mutilated cheques from which data printed in the C.M.B. code have, nevertheless, been read correctly. The code line of the cheque at the top has been completely obliterated by ordinary ink but the obscured C.M.B. characters can still be read magnetically without any difficulty

The Bull prototype sorter-reader is equipped with 24 pockets and documents are handled at 300 a minute

the magnitude of the pulse induced has no influence upon the interpretation of the code. This means that considerable variations in the amount of magnetic ink on the surface of the document can be tolerated and that badly formed or defaced characters can be read. Provided that positive pulses above a certain minimum signal intensity are received from the leading edges of each of the seven strokes, the character can be identified.

Obviously the usefulness of a printed code will in a large measure depend upon how many industries accept it as the common language. To encourage the universal adoption of the C.M.B. code, the Compagnie des Machines Bull has removed all commercial restrictions by renouncing the patents protecting the code.

As might be expected, the first machine developed by Bull was a sorter-reader for handling cheques. In common with the other codes, the C.M.B. characters are printed in one line ¼ inch above the lower edge of the cheque. Up to 40 characters may be printed in the code line, which is divided into five sections containing eight figures each. Sections are separated from each other by printed control symbols.

The prototype sorter-reader has been demonstrated in Paris on several occasions during the past year. It reads data from cheques and similar documents and sorts the latter into 24 pockets at a speed of 300 a minute. From two to six figures can be read from each document as it passes through.

As a result of the experience gained with this machine, an improved version is being developed that can handle documents of any thickness and size within the limits of approximately 6 inches by 3 inches and 8¼ inches by 4½ inches at a speed of 1,000 a minute.

A prototype imprinter for printing customers' account numbers on bank cheques in the C.M.B. code has also been built. This machine was developed jointly by Bull and Olivetti and will be manufactured in quantity by Olivetti.

The prototype sorter-reader has been used experimentally at the Le Crédit Lyonnais in Paris and it is expected that this Company will be the first to order the improved sorter-readers when they become available.

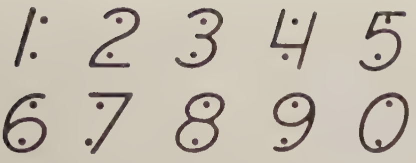
So much for machines that read print, but obviously if a machine were developed that could read handwriting this would represent a great technical advance in data transcription. Over the past few years the Bell Telephone Laboratories have been investigating the problems involved and have devised two simple reading systems. One reads hand-printed figures and the other recognizes numbers when spelt in words and written in longhand (e.g. "two" instead of 2).

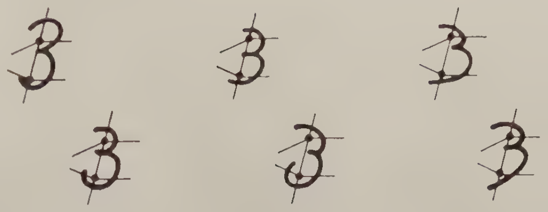
Obviously the major difficulty when reading printed or written information by machine arises from the wide variations in individual styles. Some styles are so obscure that human readers have trouble in deciphering them and it is unreasonable to expect a machine to succeed in similar circumstances. Consequently, if machine reading is to be reliable the written information must be made to conform to certain accepted standards. But this conformity must not be obtained by imposing an artificial style, because if the speed of manual writing is reduced, or a new convention has to be learnt, any advantages to be obtained from automatically reading handwritten numbers will be largely nullified.

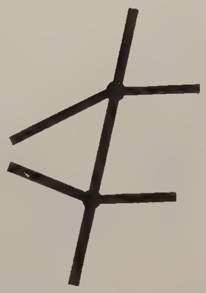
For machine reading the important factors are the location, size, orientation and shape of the hand-printed or written figures, and two simple ways of controlling these features have been devised in the Bell Laboratories.

With the first method (the reading of hand-printed figures) two dots are printed on the paper, one above the other, wherever a figure is to appear and the numeral is written round them. The shapes of the numerals and their disposition in relation to the paired dots are shown in the illustration. It will be noticed that, although the dots impose the necessary discipline on the writer, the restrictions do not seriously affect his style or speed. Examples of a few of the many different shapes of the figure 3 that can be written using this method and correctly identified by a reading machine are shown above on the right.

Numerals written in this way are identified in the following manner:—The two dots form the basis of a pattern of seven radial lines. The pattern of these seven "recognition" lines is shown on the right. One line joins the two dots together and the remaining six extend outward —three from each dot. A figure is identified by determining which of these seven lines it crosses. A photo-electric device could be built to do this, but in the early experiments two simpler methods were used.







(*Above top*) *Method of writing figures round two printed dots*

(*Immediately above*) *Examples of various handwritten forms of the figure* 3 *that can be correctly recognized and identified*

(*Right*) *Pattern of lines for recognizing hand-printed figures*

In the first, the figures are written with a graphite pencil that leaves an electrically conductive deposit on the surface of the paper. A sensing head, consisting of a number of printed wires arranged in the pattern of the "recognition" lines, is then brought into contact with the surface of the paper. Each recognition line comprises two parallel wires insulated from each other and joined to different sides of an electric circuit in a translator unit.

Wherever the graphite outline of the written characters spans the gap between two wires of a "recognition" line, the circuit is completed and a signal is sent to the translator unit. Here the combinations of signals are recognized as belonging to a particular numeral and the appropriate indicator light is turned on.

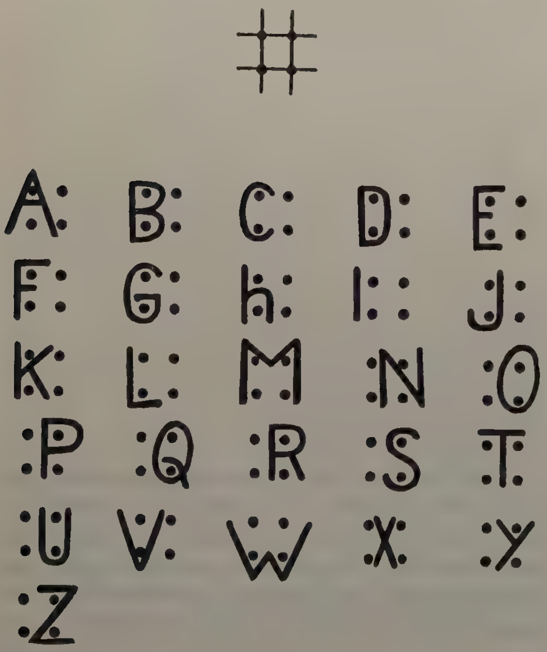
A modification of this device called a Stylator has also been built. It consists of seven conductors arranged in the pattern of the recognition lines. The conductors are embedded in a plastic board and are therefore insulated from each other. A metal stylus connected to an electric supply is given to the writer, who then goes through the motions of writing the figures directly on the surface of the plastic board. Every time the stylus passes over one of the metal conductors an electric signal is sent to the translator unit which, as before, recognizes the figure written.

Recognizing the alphabet

This method of controlling hand-printing and the technique of recognizing the figures drawn can be extended to include the full alphabet. For this purpose, however, the number of dots has to be increased to four and a pattern of 12 recognition lines is used, arranged in the form shown in the diagram below.

If, however, the letters are recognized as they are being written on a Stylator, identification is simpler since advantage can be taken of the fact that the sequence in which the recognition lines are crossed will be known. By utilizing this additional information a two-dot constraint system is sufficient to permit both letters and numerals to be accurately recognized.

Method of writing alphabetical characters round a four-dot pattern and the 12-line recognition pattern



A second, and more recent development by Bell has been the design of a device that, as mentioned earlier, can recognize numerals when spelt out in a normal handwritten cursive script. For example, the reader identifies the numeral 1 when it is written as "one." All ten decimal numerals from 0 to 9 can be recognized by this device.

Like the Stylator, this unit consists of a writing surface composed of a number of conductors embedded in an insulating material. In this case, 15 metal strips arranged in a horizontal pattern are used. As before, a metal stylus connected to an electric supply is traced over the board by the writer. And, also as before, the word is identified by a translator unit which receives a signal from each metal bar as it is crossed.

A word is recognized by its length, the sequence in which the conductors are crossed, the dotting of the letter "i" and the number and position of letters that have extended vertical strokes such as "h" and "g."

Although the device can recognize most styles of cursive script it has its limitations. For instance, the writer must not print the words, nor must he lift the stylus off the board between letters. Also, he must punctiliously dot each "i." During tests, this particular reader has correctly identified 970 words out of 1,000 written by 20 persons.

Besides the obvious commercial applications, one of the immediate objects of this research is to develop a means of logging long-distance telephone calls—a subject in which the Bell Company naturally has a great interest. It is stated that in the U.S.A. over 2,000 million call tickets, each containing from 20 to 30 characters, are written each year. It has been estimated that to transcribe this volume of data on to punched cards would cost $32,000,000 (£11,400,000). With the development of new switchboards, call tickets will eventually be eliminated, but even so they will continue to be used for many years yet. Obviously, any method that can be developed to overcome this huge data transcription problem successfully would be of immense value to the telephone industry.

Yet another experiment carried out in the Bell Laboratories was to connect a Stylator to a teleprinter. As figures are written by hand, the teleprinter types the appropriate numerals.

With such a link-up it is possible for unskilled operators to initiate and transmit Telex messages.

These then are the principal codes that have been or are still being developed for machine reading. At present, undoubtedly the greatest interest is being shown in those printed in magnetic ink. In the U.S.A., as stated, the E-13B code has been adopted by the American Bankers Association and the banks are now in the process of introducing the necessary equipment. In Europe, the banks are still investigating the problem. Shortly, the Electronics Sub-Committee of the London Clearing Banks is expected to state which of the three magnetic ink codes (E-13B, Fred or C.M.B.) it recommends for use in Great Britain.

Undoubtedly, when the banking organizations in each country make their decisions, there will be a tremendous fillip to the further development of the code, or codes, chosen.

Other applications

But, of course, banking is only one of many commercial activities, and both E.M.I. and Bull intend to continue work on their respective codes and to build machines for other business and industrial applications. In fact, some new uses are being actively considered now. One of these concerns the Fred code and the automatic routing of driver-less electric tractors—Robotugs—pulling trains of trucks. These tractors follow an electric wire when a signal of the correct frequency is being transmitted along the wire. A system of wires is laid out so that the tractor can be routed to any part of a factory or warehouse. Where two wires meet, thereby providing alternative paths for a tractor to follow, the train can be switched automatically on to the correct track by a Fred reader that identifies a destination code displayed on a board carried on the tractor.

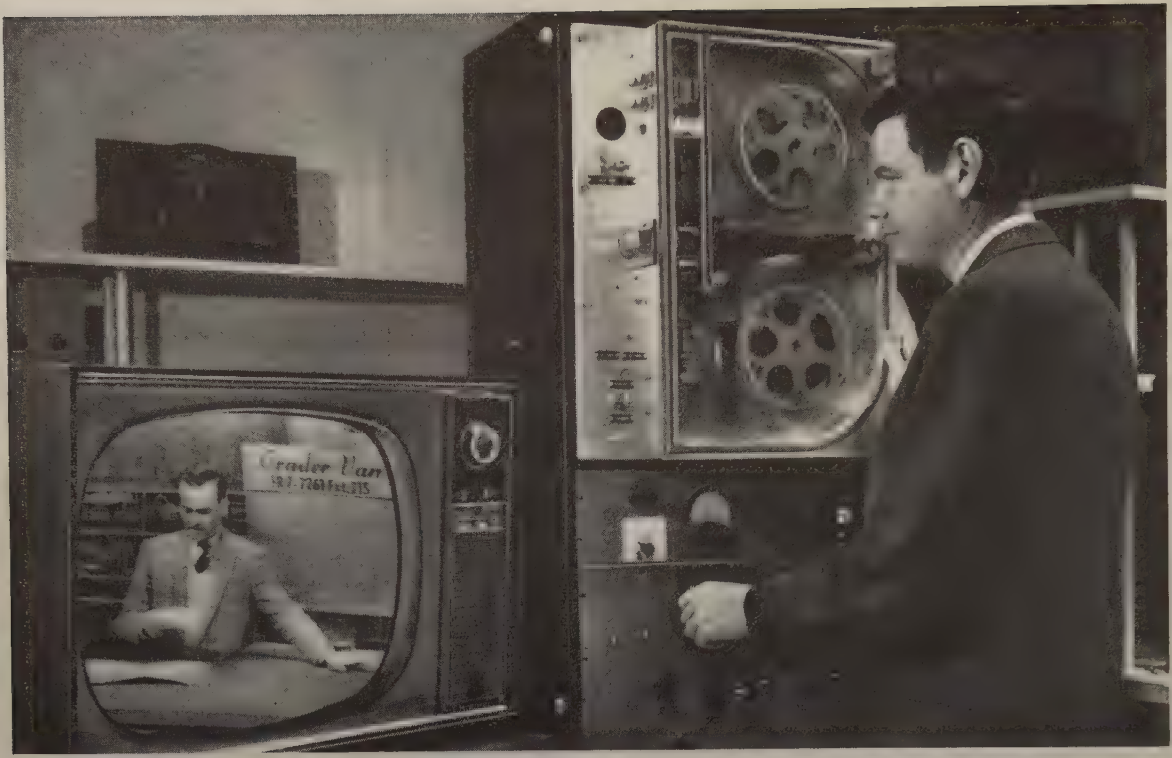
Optical reading

At present, it may seem that optical reading will never be employed extensively in commerce because of the emphasis placed on magnetic codes by the banks. This is not so. If a company is to avoid a large capital expenditure on re-equipping its offices, then obviously the automatic readers used must be capable of reading documents printed by existing business machines. For this purpose an optical reader is the better and, in some cases, the only solution.

Handwriting reader developed by Bell

A condition that favours this approach is that cash register tally rolls, stock orders and similar commercial documents, unlike cheques, are all handled within an organization and therefore overstamping and overwriting does not present the same problem that it does with documents that circulate outside an organization.

Undoubtedly, intensive development work on both optical and magnetic character readers will continue and also, as a long-term project, upon the machine reading of handwriting. However, before too many "common" languages have been evolved, it would be encouraging and also economically beneficial to the users if general agreement could be reached on the codes to be employed by different industries. It would be regrettable if, in the interest of administrative expediency, a babel of mechanical languages was created.



Recording television signals on thermoplastic tape

Thermoplastic recording

a new method of storing information: vast quantities on a single plastic tape

A combined electronic and optical method for recording and reproducing data. Potentially, an inexpensive means of storing large quantities of information in a small space. Eventually it may be possible to record and file all business documents on a few rolls of plastic tape.

Any data that can be converted into a continuous electric signal can be recorded, including both graphic data produced by a television camera and coded data produced by a computer. When finished with, recorded data can be erased and the tape re-used

THERMOPLASTIC recording offers the hope that in the near future it will be possible to reduce to a few small reels of plastic tape all the multitudinous files of commercial documents that most firms acquire. Already, the 24 volumes of the Encyclopaedia Britannica could be recorded on 200 feet of tape. From this it is apparent that the information recording density is high, and it is expected that with further development an even higher storage capacity will be achieved. However, it should be stressed that this is still a new technique. More work has to be completed before the process is considered to be suitable for commercial use.

Thermoplastic recording is a combined electronic-optical method of recording and reproducing graphic data. Digital data from a computer can also be recorded (in fact, any data that can be converted into an electric signal), but since the problem of recording and reproducing graphic information is the more difficult, the techniques developed for this purpose will be described.

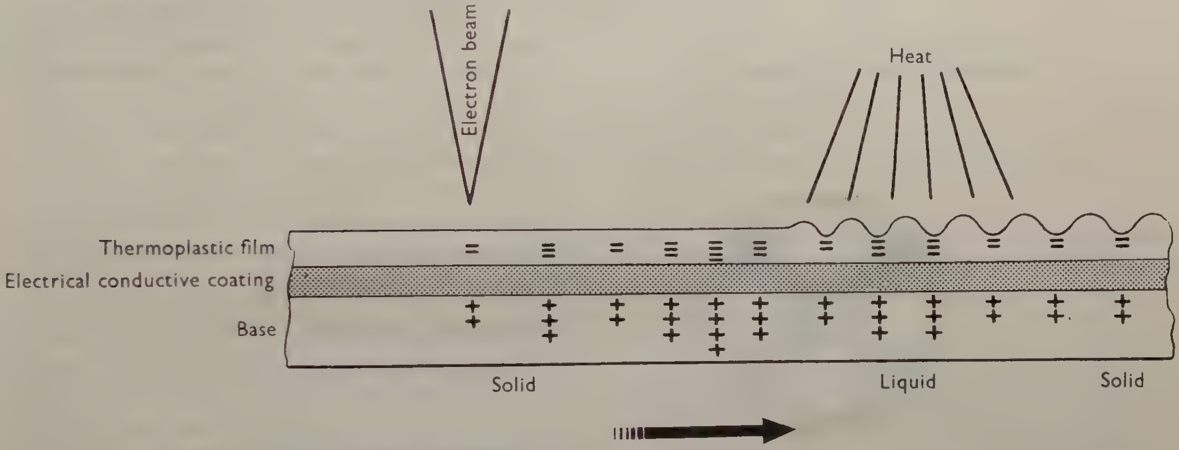
Briefly the process is as follows:—The visual image is transformed into a continuous electric signal. This signal is then used to control the intensity of an electrostatic charge pattern laid down on the surface of the thermoplastic tape by an electron gun. Next, the electrostatic pattern is converted into mechanical indentations, or wrinkles, on the surface of the tape by heating the tape until its thermoplastic surface melts. Finally, the graphic data recorded in this way can be reproduced whenever required by a special optical projection system. Either colour or black-and-white pictures can be projected or the optical signal derived from the tape can be converted, once more, into a continuous electric signal.

Thermoplastic recording was developed in the Research Laboratory of the General Electric Company (U.S.A.) at Schenectady, N.Y. It has been described as possessing many of the advantages of magnetic recording, while having the information storage facilities associated with photography. Information is recorded instantly, no chemical processing is involved, recorded information can be reproduced immediately and it can be erased and the plastic tape re-used as many times as required. In addition, when the system is fully developed, the cost of recording information in this way is expected to be low.

Special types of plastic tape are, of course, used. One form of tape employed at the moment consists of a transparent base material, such as photographic film, that can withstand high temperatures. On top of this is a transparent electrically conductive coating which, in turn, is covered with a thin layer of a low-melting-point thermoplastic material.

To record information, the tape is passed beneath an electron gun. A thin beam of electrons is focused to impinge upon the thermoplastic surface of the tape. The intensity of the projected electron beam is modulated by the electric signal representing the information to be recorded. Wherever the electron beam strikes the tape a small negative charge is left on the surface, the strength of which varies according to the intensity of the beam at that particular instant. The presence of a negative charge on the surface induces a similar charge of opposite sign (positive) in the base material.

An electrostatic force exists between these two charges and it is this force which is used to produce the wrinkles in the surface of the tape.



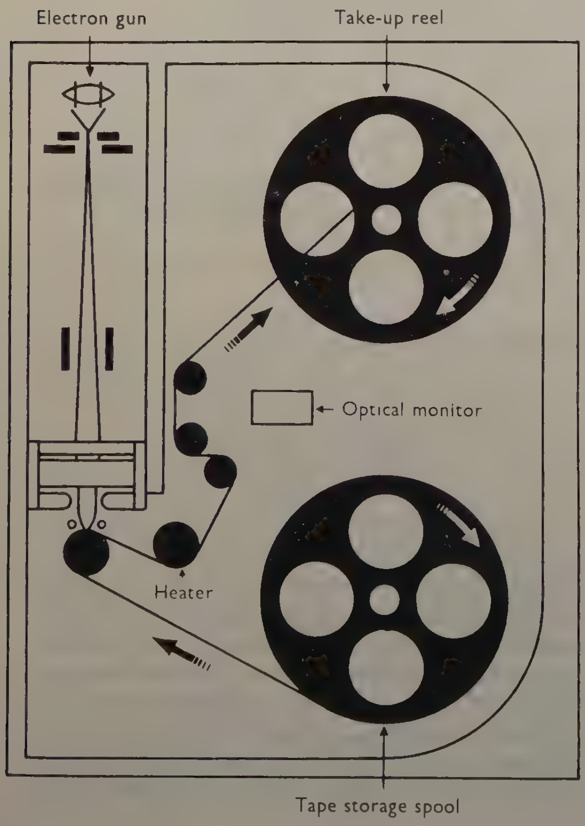
Technique used for recording information on the thermoplastic surface of the tape

To achieve this the tape is heated by inducing a heavy current in the transparent electrically conductive coating that forms the middle layer of the tape. Within a few milliseconds of the current flowing, the thermoplastic surface film is sufficiently hot for it to become completely fluid.

Wherever an impressed charge occurs on the tape, the electrostatic force exerted between the film and the base depresses the surface of the molten material. The depth of indentation produced naturally depends upon the intensity of the surface charge. After the indentations have been formed, the tape cools rapidly, permanently freezing in place the minute wrinkles created on the surface.

The method of heating the surface film by passing an electric current through a conductive sub-layer was adopted because it enables the temperature of the film to be raised and lowered extremely rapidly. The entire sequence, from the start of the heating cycle to the solidification of the surface film, is completed in less than one hundredth of a second.

Mechanism of recording machine



Normally the tape is heated and the indentations are developed on the surface immediately after the electric charges have been impressed. With some plastic materials the charge pattern persists for days; consequently it is not essential to develop the tape right away. However, if the information is converted into surface indentations at once, it is possible to monitor the results immediately afterwards and, in this way, some degree of control can be exercised over the quality of the recording that is being produced.

Erasing information

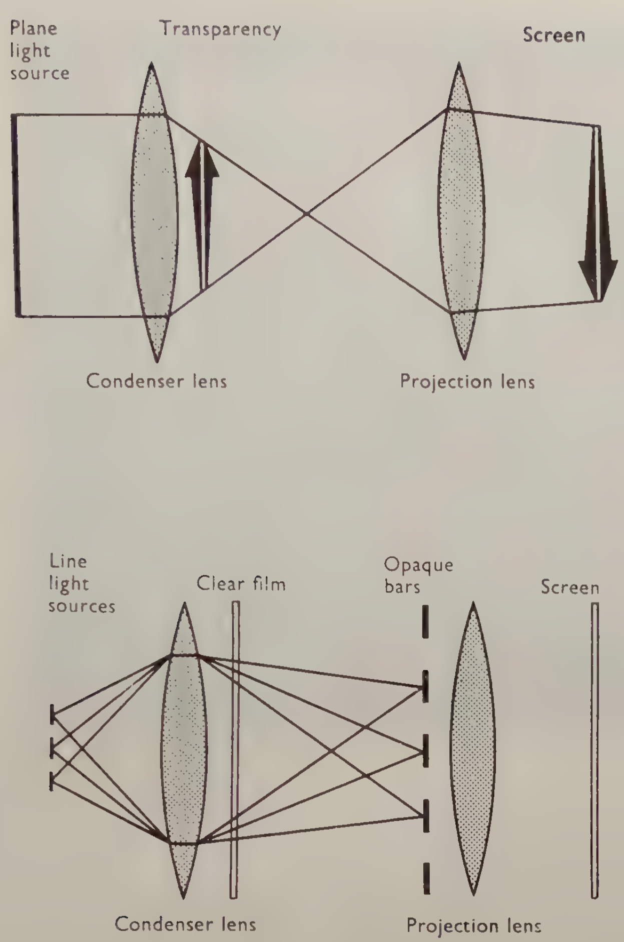
Information recorded on the thermoplastic film can easily be erased by heating the tape to a temperature well above that at which the thermoplastic melts. The recorded deformations are smoothed out and, in addition, the high temperature increases the electrical conductivity of the tape with the result that any residual electric charges remaining on the surface are dispersed. The tape can then be used again.

A machine for recording information on thermoplastic tape is shown in the accompanying illustration. Because the information is recorded on tape by an electron gun, the entire recording mechanism has to operate in a vacuum and so is installed in a sealed cabinet. After the spool of plastic tape is fitted in position, it takes a vacuum pump about one minute to reduce the pressure in the cabinet near enough to zero for the electron gun to operate effectively.

Recording sequence

When the machine is switched on, the tape is drawn from the storage spool round a reel beneath the electron gun. Here, the pattern of electrostatic charges is impressed on the surface of the tape. Next, the tape travels to the induction heater where the electrostatic charges are converted into surface indentations. After the tape has cooled, it passes through a monitor projector which reproduces the image that has just been recorded on it. And, finally, the tape is wound on to the take-up spool.

To record a picture on thermoplastic tape in this way, it is first necessary to convert the visual image into a continuous electric signal. This can be done by placing the original document before an optical scanning unit such as a television camera. The operation of the recorder and the scanner must, of course, be synchronized. As the document is scanned from



The diagram at the top shows how a conventional optical projector works. Light from a plane source is concentrated upon the transparency and an image is projected on to a screen. Below is the special projector. Light rays from a series of line sources pass through the plastic film. Rays that are not diffracted by the indentations in the surface of the film are intercepted by the opaque bars, while all the others proceed through the gaps to form an image on the screen

side to side, in a sequence of horizontal lines, so the electron beam of the recorder is controlled to sweep across the width of the plastic film. Similarly, the rate at which the tape is drawn past the electron gun is adjusted to correspond with the rate at which the document is scanned in a vertical direction. The signal produced by the scanner modulates the intensity of the electron beam; thus any variation in tonal value of the document is faithfully reproduced as a variation in the depth of the corresponding indentation produced in the plastic film.

Recording speed

At the present stage of development, tape the same size as standard 16 mm photographic film is used. Recordings are made on one half of the tape only. The width of the image recorded is 5 mm and the tape is drawn past the electron gun at a speed of 10 inches a second. Experimental recordings, without any loss of picture definition, are also being made on sections of tape 0·1 inches wide at a speed of 5 inches a second.

To convert the recorded data back into a visual image, a special optical projection system is used. The diagram above shows how a conventional projector works and, underneath, how the special projector operates. In a standard projector, light produced from a plane source passes through a condenser lens which concentrates it upon a photographic transparency. The light then passes through a projection lens which focuses the rays on to a screen to produce a sharp image of the picture on the transparency.

In the special projector, the plane light source is replaced with a number of line light sources, and a filter screen consisting of a number of opaque bars is placed between the condenser lens and the projection lens. The bars are situated relative to the line light sources so that when a plain transparency is placed in the projector all the projected light rays are intercepted and no image appears on the screen.

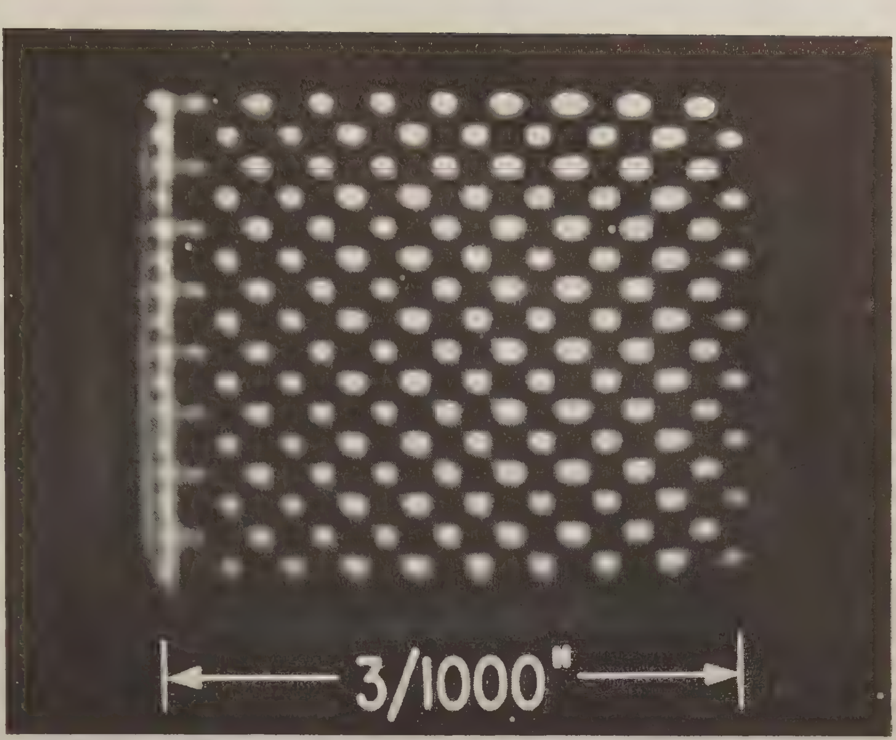
However, when a thermoplastic tape is placed in the projector, because the surface is indented, the transmitted light rays are diffracted by varying amounts as they emerge from the tape with the result that a considerable number pass between the bars of the opaque screen and produce an image on the screen. The greater the local indentation the more rays diffracted, consequently the more light projected on to the screen. In this way the tonal values recorded as a complex pattern of indentations on the tape are faithfully reproduced on the screen as spots of light of varying intensity. This makes a composition that is a faithful reproduction of the original picture.

The projector described reproduces black-and-white copies of the original. A similar projector is used to reproduce pictures in colour. In this case, however, the pattern of indentations made on the tape is more complex —deformations in the form of small diffraction gratings are recorded and the slots in the filter screen are smaller so that only one colour of the visible spectrum is transmitted through each. The spacing, or phase, of the gratings determines the colour of the picture element projected and the depth of the indentations forming the grating pattern determines the intensity.

Reproducing electric signals

When the information recorded on the tape is to be reproduced as an electric signal, a flying spot scanner is used in conjunction with an optical system of the type described. A cathode ray tube generates the flying spot and is placed in the position normally occupied by the projection screen, and the light source of the standard optical system is replaced by a photo-electric cell. The flying spot traverses the tape in the same way the electron beam does when information is being recorded. Light from the spot then passes through the optical system and is projected on the photo-electric cell. Depending upon the pattern of surface indentations encountered, so the intensity of light falling on the cell varies; this causes the cell to produce an electric signal that varies in an identical manner. The signal produced by this means is therefore similar to the original electric

Graphic information recorded on thermoplastic tape being reproduced by means of a special projector



Magnified image of digital data recorded on thermoplastic tape. It is stated that up to 40 *million bits may be recorded on one square inch of tape*

signal used to record the data on the tape. The system has been described mainly as a means of recording and reproducing graphic data. It was said at the beginning of the article that digital data received from an electronic computer could also be recorded on thermoplastic tape and an example of such a recording is shown above. Digital recordings can be re-converted into electrical pulses by the technique just described for transforming information on the tape into a continuous electric signal.

Applications

It has already been emphasized that this development is still in an early stage and that more work has to be performed before General Electric consider the system to be satisfactory. One of the immediate aims is to improve the quality of the information reproduced from the tape. But undoubtedly, even now, thermoplastic recording possesses many unusual attributes that make it suitable for various specialized applications. It has been suggested that, if a thermoplastic recording unit were installed in an earth satellite, much more information could be obtained from outer space. Information collected during an orbit would be recorded on tape and after it had been transmitted back to earth the information could be erased from the tape and the process repeated. It is also extremely likely that thermoplastic tape will be intensively developed for military applications—for example, to provide multiple displays on large screens of radar, sonar and infra-red pictures, also to record in compact form pictures taken by aerial reconnaissance cameras.

Although, initially, thermoplastic tape is likely to be used for scientific and military purposes, it offers the business world many advantages. Today, the cost of storing business papers is high—higher than many people care to admit—and the pressure exerted by having to provide filing space when the available office accommodation is limited, makes the retention of complete historical commercial records something of a luxury. Thermoplastic recording may alter this situation. In addition, and for similar reasons, thermoplastic recording may be adopted by computer manufacturers because thermoplastic tape provides compact permanent information storage capacity at a reasonable cost, and offers the further advantages that data can be recorded or erased at high speed and the tape is re-usable.

Automatically up-dating account

A description of the fully automatic Post-Tronic accounting machine

The National Cash Register Company has produced two units which when added to a Post-Tronic accounting machine make it fully automatic. Transaction data are read from punched paper tape, the appropriate account card is selected, the account data are read magnetically from the back of the card and the new balance is calculated and printed, together with a complete record of the transaction, on three documents—a ledger card, a statement of account and a journal sheet. All these operations are performed continuously and automatically; the only task the supervisor has to do is to load and unload the account cards.

Priced at £12,500, this equipment brings automatic account record-keeping within the compass of a branch bank or divisional sales office. In the past it has been assumed that centralized administration was essential in order to obtain the benefits of automatic accounting. With the introduction of the fully automatic Post-Tronic this no longer applies

NATIONAL Cash have introduced a punched paper tape reader and a document feed unit which when connected to a standard Post-Tronic accounting machine convert it into a fully automatic machine. With this assembly, several hundred account entries can be posted every hour. Information about new debits and credits is obtained from a punched paper tape, the correct ledger card and customer statement is located, the entry is printed on the next free line and the new balance is calculated and printed in the correct columns. Finally, a complete continuous printed record of every transaction is recorded on a journal sheet. All these operations are performed automatically; the only work the operator or supervisor has to do is to load and unload the account record cards from the document feed unit and fit reels of punched paper tape to the reader. At the end of the day, or whenever required, totals of the value of the debits and credits posted can be obtained from information storage registers fitted to the machine. These figures are printed on the journal sheet together with any other control totals needed. The total number of postings made, and the number of credit and debit amounts entered, can also be obtained from a group of four mechanical counters.

The complete system costs £12,500 and is estimated to perform the work for which seven operators equipped with conventional mechanical accounting machines are normally required. It is also stated that a supervisor can control three fully automatic Post-Tronics.

This tremendous increase in the volume of work that can be handled by what is still, basically, a keyboard accounting machine is brought about by utilizing electronic data storage and handling techniques and by mechanizing those functions normally performed by the operator.

One of the most important features of the Post-Tronic is that it halves the work because entries are made on the ledger card and the customer's statement simultaneously. Normally, of course, with the conventional type of manually operated accounting machine these two documents are up-dated separately and then the two balance totals are compared to see if they agree—a procedure that has to be adopted to confirm that data transcribed manually have been transcribed correctly.

Among the advantages claimed for the automatic Post-Tronic are these:—It is an economic proposition to install a machine of this type in a branch bank or divisional sales

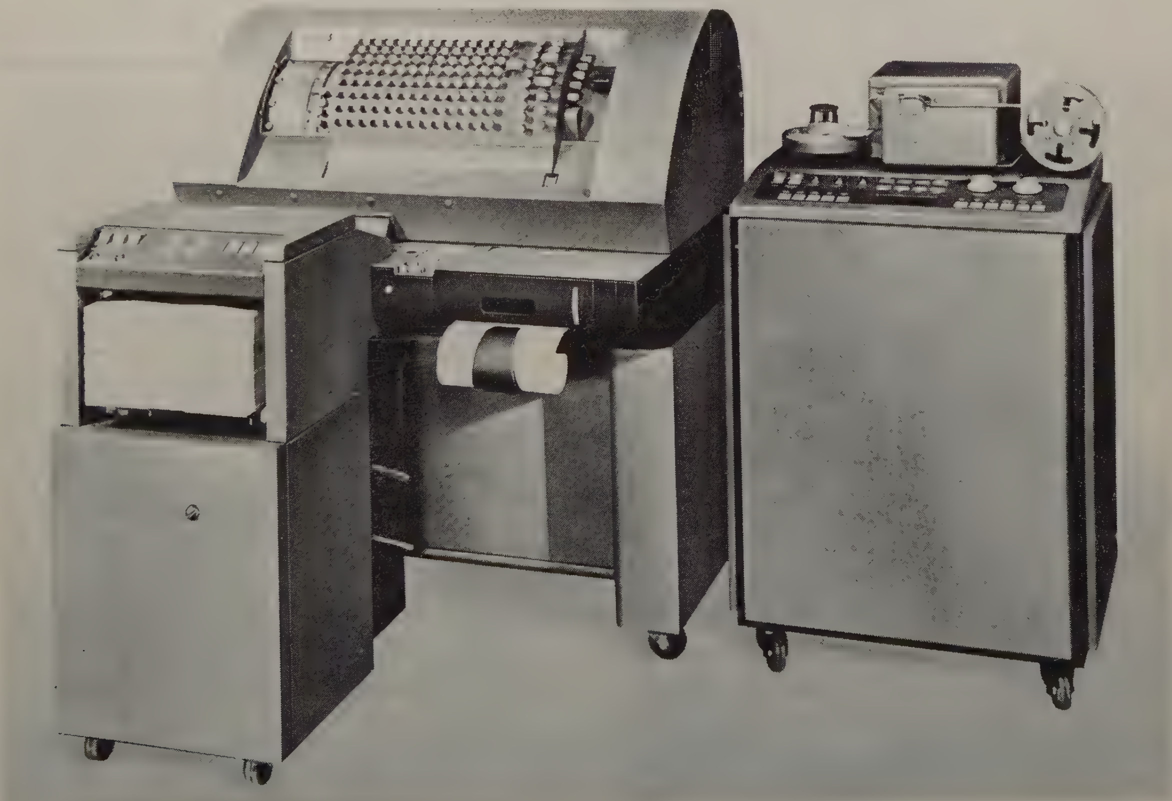
records without a computer

office because the initial cost is not high and the capital invested can be recovered within a reasonable time; automatic record keeping is attained without the necessity to centralize the accounting procedures; details of every transaction are printed directly on the documents in everyday use; the system can be built up unit by unit, starting with a manually operated Post-Tronic.

In addition, of course, the system possesses all those features associated with the Post-Tronic itself.* These are that the following operations are performed entirely automatically:—The selection of the correct account card is verified, the card is fed into the correct printing position, the current balance is picked up and the new balance is calculated and printed in the correct columns.

One of the most important items of a Post-Tronic system is the card on which the account record is printed. It measures 12 inches by $10\frac{5}{16}$ inches and is a dual-purpose document. On the left is printed a complete record of the account. All credit and debit entries are listed, together with the various balance totals. This is the customer's statement. An identical list of entries is printed on the right of the card and this is the bank ledger card. When the card is full, or when a statement has to be issued, the current data are transferred on to a new account card and the original card is guillotined down the middle—the left-hand portion is sent to the customer and the right-hand portion is retained.

The fully automatic Post-Tronic accounting machine system



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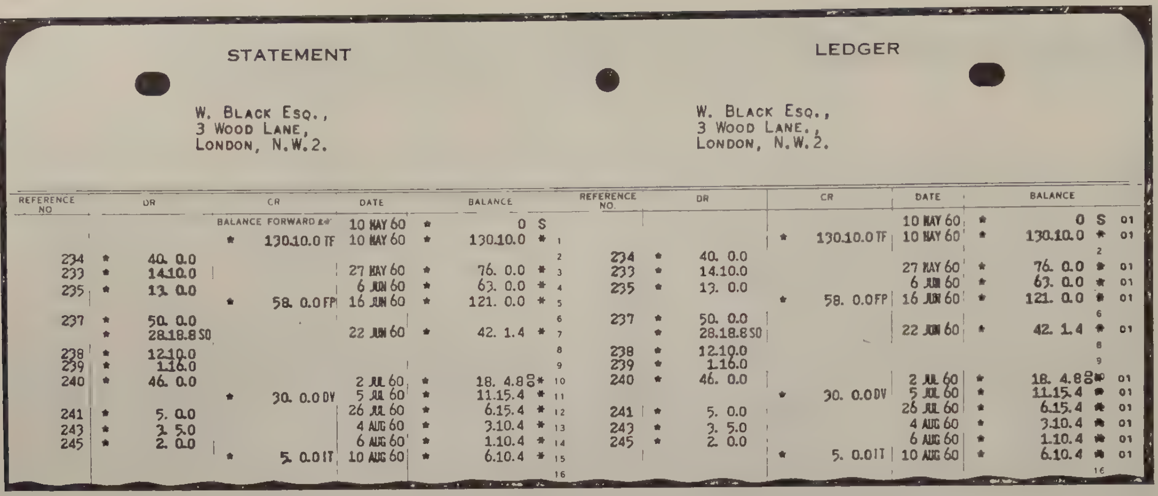
*A description of a manual Post-Tronic application is given in the article "Branch bank accounting," on page 238 of this issue.



STATEMENT

W. BLACK ESQ.,
3 WOOD LANE,
LONDON, N.W.2.

REFERENCE NO	DR	CR	DATE	BALANCE	
		BALANCE FORWARD £	10 MAY 60 *	0 S	
		* 130.10.0 TF	10 MAY 60 *	130.10.0 *	1
234	* 40. 0.0				2
233	* 14.10.0		27 MAY 60 *	76. 0.0 *	3
235	* 13. 0.0		6 JUN 60 *	63. 0.0 *	4
		* 58. 0.0 FP	16 JUN 60 *	121. 0.0 *	5
237	* 50. 0.0				6
	* 28.18.8 SO		22 JUN 60 *	42. 1.4 *	7
238	* 12.10.0				8
239	* 1.16.0				9
240	* 46. 0.0		2 JUL 60 *	18. 4.8 *	10
		* 30. 0.0 DV	5 JUL 60 *	11.15.4 *	11
241	* 5. 0.0		26 JUL 60 *	6.15.4 *	12
243	* 3. 5.0		4 AUG 60 *	3.10.4 *	13
245	* 2. 0.0		6 AUG 60 *	1.10.4 *	14
		* 5. 0.0 IT	10 AUG 60 *	6.10.4 *	15
					16

LEDGER

W. BLACK ESQ.,
3 WOOD LANE.,
LONDON, N.W.2.

REFERENCE NO.	DR	CR	DATE	BALANCE	
			10 MAY 60 *	0 S	01
		* 130.10.0 TF	10 MAY 60 *	130.10.0 *	01
234	* 40. 0.0				2
233	* 14.10.0		27 MAY 60 *	76. 0.0 *	01
235	* 13. 0.0		6 JUN 60 *	63. 0.0 *	01
		* 58. 0.0 FP	16 JUN 60 *	121. 0.0 *	01
237	* 50. 0.0				6
	* 28.18.8 SO		22 JUN 60 *	42. 1.4 *	01
238	* 12.10.0				8
239	* 1.16.0				9
240	* 46. 0.0		2 JUL 60 *	18. 4.8 *	01
		* 30. 0.0 DV	5 JUL 60 *	11.15.4 *	01
241	* 5. 0.0		26 JUL 60 *	6.15.4 *	01
243	* 3. 5.0		4 AUG 60 *	3.10.4 *	01
245	* 2. 0.0		6 AUG 60 *	1.10.4 *	01
		* 5. 0.0 IT	10 AUG 60 *	6.10.4 *	01
					16

The dual-purpose account card. On the left is the customer's statement and on the right the ledger card

These two documents are handled in the normal way and the record of the account is printed on them in the conventional manner—credits in black, debits in red. The unconventional feature of the combined ledger card and statement is that on the back are printed ten stripes of magnetic ink, each half an inch wide by approximately seven inches long. On these stripes are recorded magnetically the pertinent current information relating to the account. Thus the current data are recorded on the card in two forms—in print for the benefit of the human clerks and magnetically for the benefit of the Post-Tronic.

Information is recorded on the stripes in a decimal positional code: that is, a pulse can be recorded in any one of ten positions, each of which represents a particular decimal value. As two decimal digits can be recorded in each stripe, a total of 20 digits may be stored magnetically on the back of each account record card.

Data recorded on the stripes are the last three digits of the customer's account number, the current balance (up to 10 digits), a + or — sign to indicate credit or debit, and the number of the line on which the next entry is to be printed (two digits). Each card can accommodate 40 printed entries and the lines are numbered accordingly.

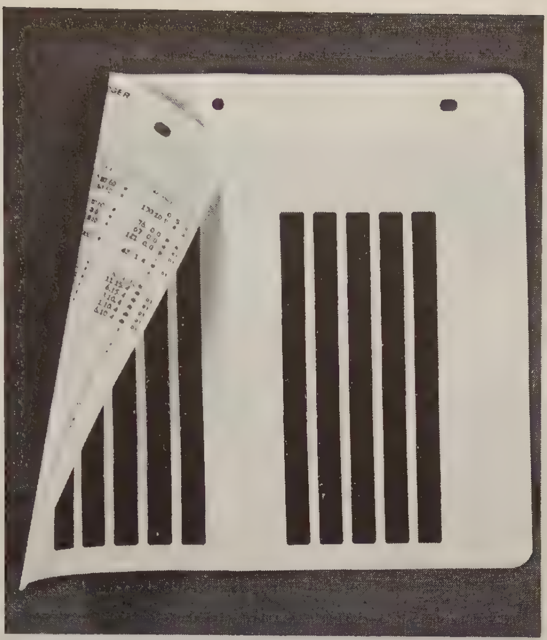
A fully automatic Post-Tronic operates in the following manner. A stack of ledger cards in account number order is placed in the hopper of the document feed unit. A spool of punched paper tape that contains a list of debit and credit entries, also in account number order, is fitted to the reader and the machine assembly is switched on.

The last three digits of the first account number are read from the paper tape and sent to a comparator store. Simultaneously, the first ledger card is fed automatically on to the printing table of the Post-Tronic. As the card is picked up and passed into the Post-Tronic, magnetic heads read the last three digits of the account number from the appropriate magnetic stripes on the back of the card, and this number is compared with the one already held in the comparator store. If the two numbers are different, the account card is rejected from the machine and returned to an output hopper in the bottom of the document feed unit. Then the next account card is fed on to the Post-Tronic printing table and the procedure repeated.

This continues until the card with the required account number is detected. When this occurs, the current balance and the line number on which the next entry is to be printed are read from the back of the card and the balance total is transferred to an arithmetic unit. At the same time the card is positioned so that the next entry will be printed on the designated line. Then the amount and type of transaction (whether credit or debit) are read from the punched paper tape and these data are relayed to the arithmetic unit where the new balance is calculated.

The Post-Tronic prints two complete records of the transaction on the account card (the ledger entry and the customer statement entry) and a third record on the journal sheet. All three entries are printed simultaneously and, since the printing heads are interconnected mechanically, it is impossible for the data on the three documents to disagree.

Sometimes two or more consecutive entries in the paper tape will refer to the same account number. In this case a card retention code is punched after each entry. Whenever this code is read, the account card is advanced one line and a record of the next entry is printed on the card. This continues until a new account number is read from the tape. Thereupon the total compiled in the arithmetic unit—the new balance—is printed in the appropriate columns of the account card and, simultaneously, the corresponding data are magnetically recorded on the magnetic ink stripes. Then the account card is ejected from the Post-Tronic and stored in one of the two output hoppers of the document feed unit. After this, the last three digits of the new account number which initiated this action are entered into the comparator register and the operational cycle begins again—account cards are fed into the Post-Tronic until the correct one is located, the account is up-dated and the card is ejected. The entire up-dating procedure is continuous and automatic.



Ten magnetic-ink stripes are printed on the back of each account record card

The automatic document feed unit can hold 1,000 cards

Transaction entry

A typical printed entry contains these items of information: a reference number (identifying the cheque or deposit slip), the amount ~~of~~ the credit or debit, the date (this is pre-set manually on four dials provided on the Post-Tronic's control panel before the start of the day's postings) and the current balance.

The speed at which entries are completed depends principally upon the rate at which the account cards can be fed into and out of the Post-Tronic. The search time is 1·33 seconds per card. This is the time taken to feed a card into the machine and reject it if it does not bear the required account number. To feed a card into the machine, post one item and eject the card takes 6·2 seconds. To perform the same operation but post two items takes 7·4 seconds. Thereafter any further entry on the same card takes an additional 1·2 seconds to complete. When a trial balance is being performed, the time required to read the balance from each card is 1·33 seconds.

Naturally the overall speed of performing a particular job depends upon the nature of the work. Where an average of two entries are

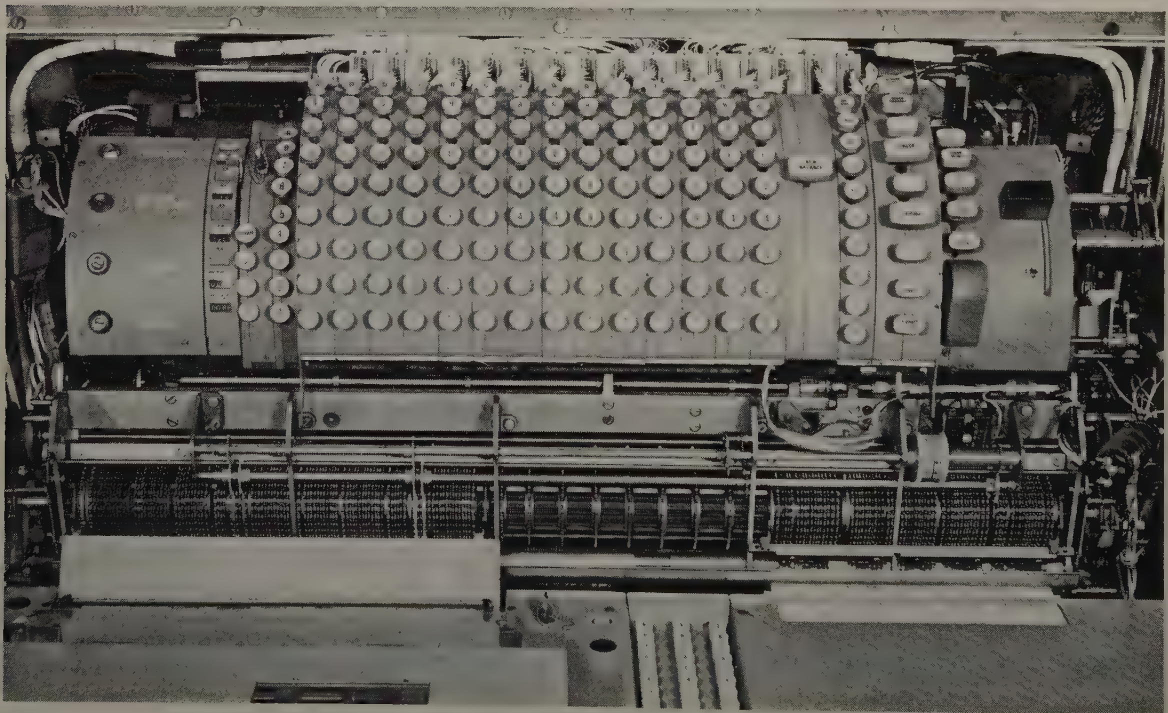
Programme selector switch

being posted to every alternate account, about 840 accounts can be handled an hour—that is about 7,000 accounts during a normal 8½ hour working day.

Up-dating accounts is the work for which the machine was designed, but many other related accountancy jobs can be tackled. A six-position programme switch is fitted to the Post-Tronic and by turning this knob the supervisor can set up the machine to perform other types of work.

When statements are to be issued, the current data have to be carried forward on to new cards. With the programme control switch set to "Trans," this data transfer operation is performed automatically. New cards interleaved with the old cards are placed in the hopper of the document feed unit. When the machine is switched on, the first ledger card is fed into the Post-Tronic, the current data are read from it and stored in the machine and then the card is ejected. Next, the new card is fed into the Post-Tronic and the data held in store are printed on the front of the card and simultaneously recorded magnetically on the back. The

The printing head spans almost the entire width of the Post-Tronic. Three documents are printed simultaneously



new account card is then ejected and the operational cycle is repeated with the next pair of cards.

Another programme controls the accumulation of totals for a trial balance. The programme switch is turned to "Trial B" and the desired section of account cards is placed in the document feed unit. After the machine has been switched on, the outstanding balance is read from each card in turn and the information is sent to the appropriate storage registers in which the various totals of the credit balances and the debit balances are being compiled. A combined total is also derived and, at the end of the operation, these figures are printed on the journal sheet.

With the switch set in the position "Add," all the electronic circuits within the Post-Tronic are isolated and the machine can then be used as a manually operated multi-register adding-listing machine.

Another position of the switch is labelled "Install." As the name implies, this setting is used only when the system is being installed and data have to be transcribed on to the account cards by operating the keyboard of the machine manually. This position of the programme switch is also selected when cards are being prepared for new accounts.

The remaining two positions on the programme switch are "Postg 1" and "Postg 2." "Postg 1" is the position of the switch when normal posting operations are being performed either manually or automatically. "Postg 2" is a special position used only when the Post-Tronic is being operated manually.

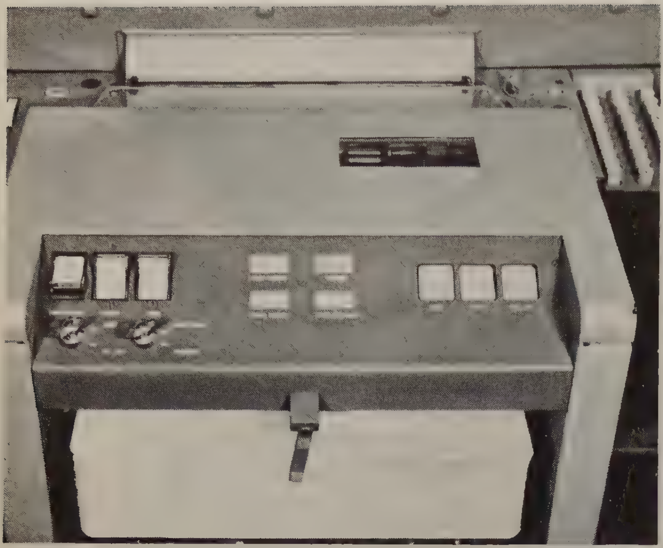
These six programmes cover the complete range of standard book-keeping operations, but special programmes can be devised to suit particular accountancy applications should this be necessary.

Printing head

The Post-Tronic is equipped with an unusual printing head. It has already been mentioned that three records of each entry are printed directly upon the appropriate documents. No carbon copies are produced and none are needed. This is because the printing head spans almost the entire width of the Post-Tronic and a separate group of print wheels is provided for every column of all three documents. The documents are printed side by side and the wheels that print identical information are interlocked mechanically so that there is no possibility that the figures in one entry can differ from the corresponding figures in the other two entries.

After the account cards have passed through the Post-Tronic they are sorted into two output hoppers

One of the important ideas behind the design of this system is that it is expandable. Though the basic Post-Tronic is a manually operated machine, it is used as the central unit in the automatic system. This means that the user can start with a basic machine and, when the work load increases, convert it into a fully automatic system simply by adding a document feed unit and a punched paper tape reader. Alternatively, progress can be more gradual. By fitting a document feed unit only, a semi-automatic system is created. With this installation, operations such as trial balancing and balance transfers are performed completely automatically, while the operator up-dates account records manually, as before.



Control panel of document feed unit

The input hopper of the document feed unit can accommodate 1,000 account cards. At the rear of this unit are two output hoppers into which cards are directed after they have been ejected from the Post-Tronic. During the posting run, account cards to be brought to the attention of the management are automatically segregated from the remainder and are stacked in the second hopper. Such cards, of course, can be ones belonging to accounts in debt.

Entries are never made on cards belonging to stopped accounts. A special code signal is recorded magnetically before the account number on all cards against which a stop order has been placed or which belong to closed accounts. When such a card is fed into the Post-Tronic, the stop code is read first and the machine refuses to accept the document. At the same time a warning light is illuminated and the machine waits for the operator to withdraw the card and re-start the operation.

When the last card has been despatched from the document feed unit and all the operations on it have been completed, the Post-Tronic automatically switches itself off. The start-stop buttons that control the system are located on a panel fitted to the document feed unit.

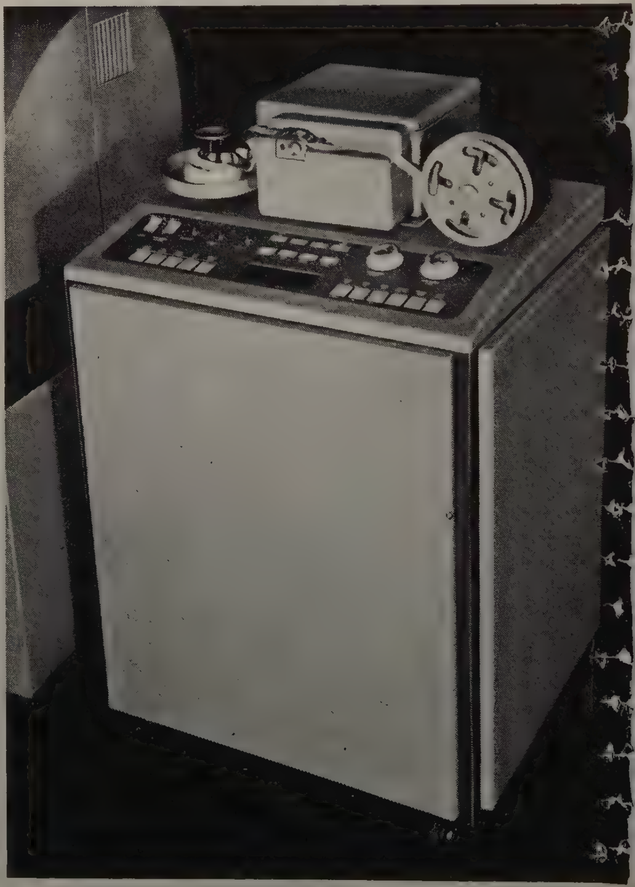
All transaction data are punched in 5-channel paper tape. Every digit is represented by a four-bit code group and parity check bits are punched in the fifth channel. The parity rule is that there must be an odd number of holes in each row punched in the tape.

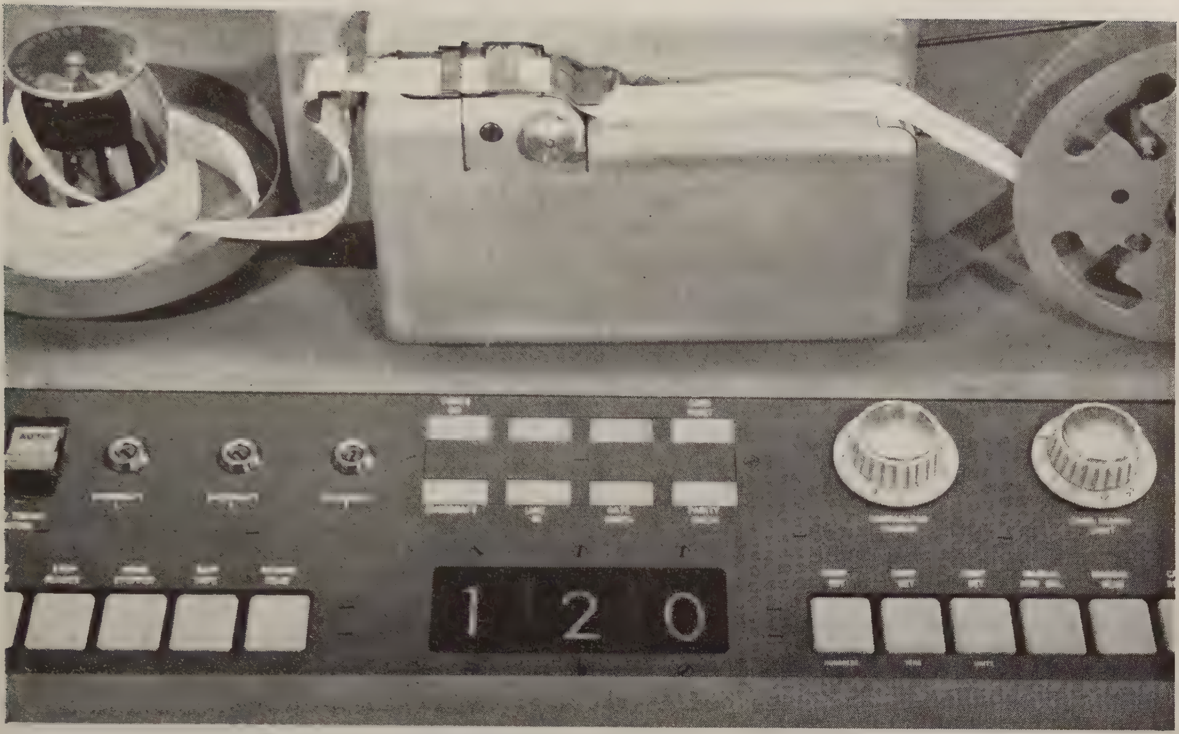
Data recorded in the paper tape are the last three digits of the customer's account number, the amount (up to 10 digits), transaction code (1 digit), reference number (3 digits—this identifies the cheque or deposit slip) and description (2 digits). The transaction code indicates whether a cheque or deposit is involved, and the description identifies the type of charge—bank charge, standing order and so on.

A six-inch diameter reel holds 300 feet of paper tape which is sufficient for about 2,500 transaction records. When the machine is in operation, the supervisor can see how far the job has progressed as the last three digits of the next account number to be supplied to the Post-Tronic are displayed on the control panel of the tape reader.

Before the automatic Post-Tronic can be used, all the transaction data have to be recorded in punched paper tape in account

Punched paper tape reader





The last three digits of the account number are displayed on the control panel of the tape reader

number order. This can be achieved by any one of several methods. In the case of a bank, the local branch receives cheques and deposit slips in random order and one of the first jobs that has to be performed is to sort out the cheques belonging to other banks and return them to a clearing department accompanied by a list showing the individual amounts and a total for the batch. For accounting control purposes it is also necessary to prepare a similar list of those cheques that belong to the bank. And it is at this stage that transaction data are captured and punched in paper tape.

Capturing transaction data

First, the cheques are manually sorted into order; then they are listed on an adding-listing machine to which is connected a 5-channel paper tape punch. As each entry is made, the account number, amount, document reference number, transaction code and description are punched in the tape. This operation is performed, preferably, once a day.

Another and more sophisticated method of recording transaction data in paper tape is possible for those banks that use cheques on which all the information is printed in magnetic ink (see page 208 of this issue). The cheques are first arranged in order by a sorter-reader and then, during a subsequent operation, the necessary punched paper tape is produced on a sorter-lister-converter.

This procedure of listing the cheques to obtain accounting control totals is already performed in the banks and very little additional work is involved in recording these data in paper tape during the listing operation.

The automatic Post-Tronic system demonstrated in Great Britain recently was for decimal currencies. A sterling machine is being developed and will be available in 1962.

The first two automatic Post-Tronics have just been installed in the offices of The Chemical Bank New York Trust Company, together with a National sorter-reader operating with the E-13B printed characters approved as the common language code by the American Bankers Association. It is likely that the first sterling machine systems will also be ordered by banks, though of course the equipment may be used equally well by other businesses faced with similar current account record-keeping problems.

Branch bank accounting

The new generation of electronically operated keyboard accounting machines—how they are used by the Chartered Bank, of Great Britain

By P. A. Spooner

Two Post-Tronic accounting machines have taken over the work formerly carried out on three mechanical accounting machines. Even so, these two Post-Tronics are not fully employed and it is expected that after the administrative procedure has been modified these two machines will replace five conventional accounting machines.

Post-Tronics are among the first examples of an entirely new design of keyboard accounting machine that utilizes some of the electronic data-handling techniques originally developed for the digital computer. Account data are recorded magnetically on the backs of otherwise conventional ledger cards that are in everyday use within the bank. This information is read automatically when the ledger card is fed into the machine and checked against similar data entered on the keyboard by the operator. Thus the machine guards against the operator feeding in the wrong ledger card. The machine ensures that the current balance is picked up correctly and, at the completion of an entry, it calculates, prints and magnetically records the new balance on the ledger card

British banks are at the beginning of a far-reaching automation programme and major decisions have now to be made. For some time they have been investigating new ways of dealing with the rapidly increasing volume of work and evolving means of combating severe shortages of staff and space. Inevitably, the computer and the electronic cheque-sorter have captured much of their attention. But such equipment, in its present form, cannot be used economically without a high degree of centralization and for this reason many banks are now showing greater interest in the development of small data processing machines which can be used, where necessary, in more localized ways. One machine of this kind is the National Post-Tronic.

The Post-Tronic prints transaction data on the ledger card and the customer's statement of account simultaneously

Mr. Spooner is with the National Cash Register Company Limited.

The Post-Tronic employs a mixture of mechanical book-keeping and electronic techniques to produce the ordinary printed records that are a pre-requisite of day-to-day bank operations. In its basic form, the Post-Tronic requires a full-time operator; but it can handle the work for which three conventional accounting machines are normally required. The increase in working speed results mainly from the entirely new type of magnetic memory used.

Four years ago the prototype Post-Tronic was demonstrated for the first time at the American Bankers Association's annual convention. To-day about 6,000 of these machines are at work in over 1,000 different banks in the United States and it is estimated that at least one-quarter of all American cheque account statements are now produced on equipment of this type. Recently the first installations have been completed in the U.S.A. of a new fully automated version of the Post-Tronic. Incidentally, a short time ago this latter machine was demonstrated in London, it is described in greater detail on page 230 of this issue.

Installations of standard Post-Tronics range in size from batteries of over 100 machines—working in circumstances which would readily justify the use of a large-scale electronic computer—to single machines which have made automation a practical proposition for the branch bank.

In Great Britain, in spite of fundamental differences in the organization of bank work, a similar interest in these machines is being shown. Among the first users are two members of the "Big Five" and two of the smaller, more specialized banks.

One of these latter is the 107-year-old Chartered Bank, of Bishopsgate, London, E.C.4, which installed two Post-Tronics in April this year. These machines are now processing the accounts of the Bank's own employees and pensioners, together with various other internal accounts. By restricting the machines to work of this kind the bank is giving itself an opportunity to evaluate the true capabilities of the equipment and also to examine the changes in procedure which will enable the equipment to be employed most profitably—changes which, it is now believed, will achieve significant savings in their own right.

Meanwhile, there has been a definite speeding-up in the rate at which the initial work placed on the machines is being handled. Much of this is due to the elimination of the double-posting operation which was previously needed to ensure that, even when experienced operators were employed, errors were kept to a reasonably low level.

Foolproof working is, in fact, a major asset of the Post-Tronic. It disposes of the two main bugbears of bank accounting by confirming that the operator has selected the correct account before a credit or debit entry is made and by ensuring that the old balance is picked up correctly.

The Post-Tronic occupies the same floor-space as a conventional accounting machine and weighs about 550 lb. Power is taken from the normal electric supply and the machine can be used in an ordinary office without air-conditioning or other special facilities.

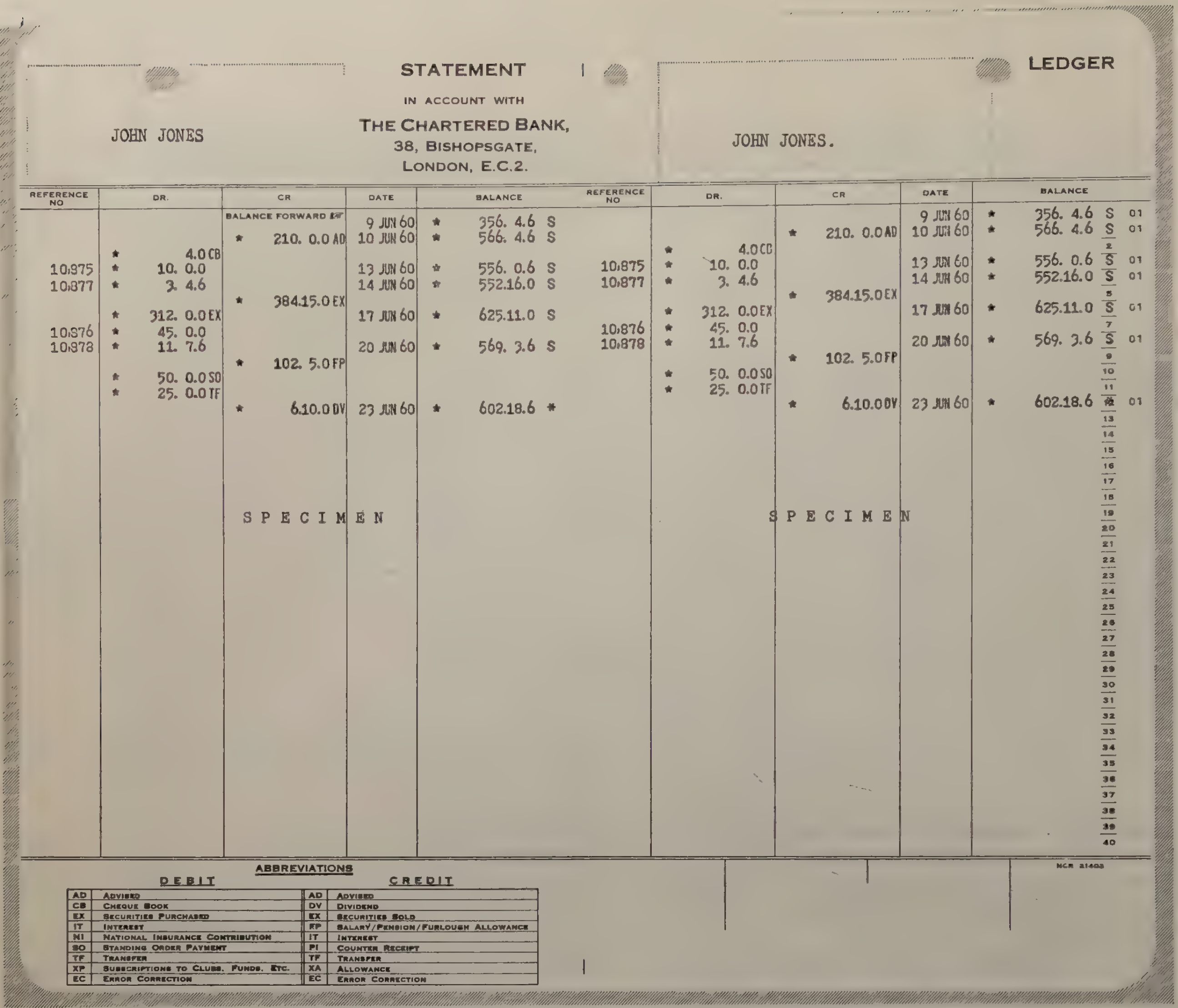
The electro-mechanical part of the equipment is expressly designed for account posting. Basically, the amount to be credited or debited is entered on a keyboard and either added to or subtracted from the old balance which has previously been picked up automatically and stored in one of the machine's registers. The result of this calculation—the new balance—is then printed out.

Documents printed

Information is printed on a combined ledger card and customer's account statement and also on a continuous journal sheet. The information is printed directly on all three documents simultaneously; no carbon paper is used and no repeat printing operations are performed. This is possible because the Post-Tronic is equipped with 12 printing heads. No carriage movement is needed, separate print wheels being provided for every column on the three documents.

Where the Post-Tronic differs fundamentally from a conventional accounting machine is that built-in electronic circuits perform three operations which otherwise have to be performed manually. The Post-Tronic verifies the selection of the account by comparing the account number on the combined ledger card and statement with that on the posting voucher; it picks up automatically and verifies the old balance; and finally it automatically feeds the combined ledger card and statement to the correct printing position. The information which controls these three operations is read electronically from the ledger card.

On the back of each card is imprinted ten vertical stripes of magnetic ink which, in effect, act as short lengths of magnetic tape. On these stripes are recorded magnetically the account



STATEMENT

IN ACCOUNT WITH

THE CHARTERED BANK,
38, BISHOPSGATE,
LONDON, E.C.2.

JOHN JONES

REFERENCE NO	DR.	CR	DATE	BALANCE
		BALANCE FORWARD ☞	9 JUN 60	* 356. 4.6 S
		* 210. 0.0 AD	10 JUN 60	* 566. 4.6 S
	* 4.0 CB			
10,875	* 10. 0.0		13 JUN 60	* 556. 0.6 S
10,877	* 3. 4.6		14 JUN 60	* 552.16.0 S
		* 384.15.0 EX		
	* 312. 0.0 EX		17 JUN 60	* 625.11.0 S
10,876	* 45. 0.0			
10,878	* 11. 7.6		20 JUN 60	* 569. 3.6 S
		* 102. 5.0 FP		
	* 50. 0.0 SO			
	* 25. 0.0 TF			
		* 6.10.0 DV	23 JUN 60	* 602.18.6 *

SPECIMEN

LEDGER

JOHN JONES.

REFERENCE NO	DR.	CR	DATE	BALANCE	
			9 JUN 60	* 356. 4.6 S	01
		* 210. 0.0 AD	10 JUN 60	* 566. 4.6 S	01
	* 4.0 CB				
10,875	* 10. 0.0		13 JUN 60	* 556. 0.6 S	01
10,877	* 3. 4.6		14 JUN 60	* 552.16.0 S	01
		* 384.15.0 EX			
	* 312. 0.0 EX		17 JUN 60	* 625.11.0 S	01
10,876	* 45. 0.0				
10,878	* 11. 7.6		20 JUN 60	* 569. 3.6 S	01
		* 102. 5.0 FP			
	* 50. 0.0 SO				
	* 25. 0.0 TF				
		* 6.10.0 DV	23 JUN 60	* 602.18.6 *	01

SPECIMEN

NCR 21402

ABBREVIATIONS

DEBIT		CREDIT	
AD	ADVISED	AD	ADVISED
CB	CHEQUE BOOK	DV	DIVIDEND
EX	SECURITIES PURCHASED	EX	SECURITIES SOLD
IT	INTEREST	FP	SALARY/PENSION/FURLOUGH ALLOWANCE
NI	NATIONAL INSURANCE CONTRIBUTION	IT	INTEREST
SO	STANDING ORDER PAYMENT	PI	COUNTER RECEIPT
TF	TRANSFER	TF	TRANSFER
XP	SUBSCRIPTIONS TO CLUBS, FUNDS, ETC.	XA	ALLOWANCE
EC	ERROR CORRECTION	EC	ERROR CORRECTION

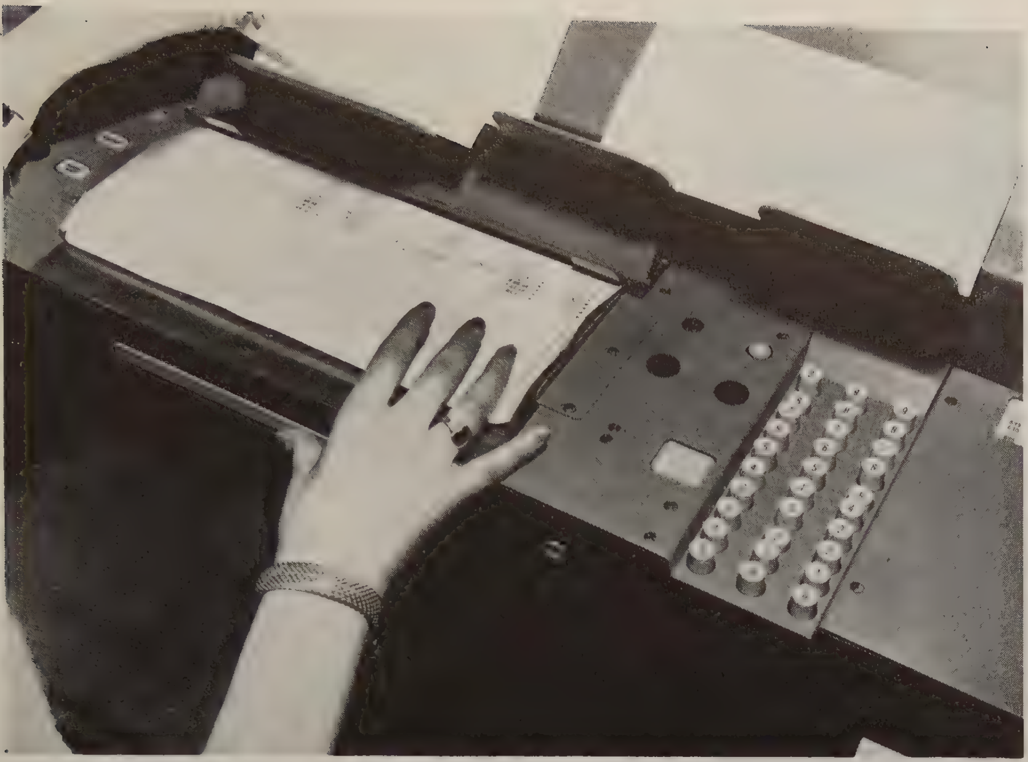
Combined ledger card and customer's statement. Account data are also recorded magnetically on the back of this document

number, current balance, and printing position. Up to 20 decimal digits of information can be recorded on these stripes.

As the ledger card is fed into the correct printing position the data are read from the stripes and these signals control the electro-mechanical parts of the equipment. After a posting operation has been carried out, the old information is erased from the stripes and the account number, new balance and new printing position are recorded in readiness for the next posting operation.

The magnetically recorded information is "permanent" in that there is no danger of its fading under normal card storage conditions, even if the account is inactive for a long period. To the right of the printing table is a small keyboard called the comparator keyboard. It comprises three columns of keys numbered from 0 to 9 and may be used as an electronic data input device, enabling information to be magnetically encoded on the cards when, for example, new accounts are opened.

The main keyboard, similar in design to that of other National account posting machines, is divided into several sections. The first five rows are used for inserting the reference numbers of the cheques. Then comes an amount keyboard containing eleven rows of keys on which amounts up to a maximum of £9,999,999 19s. 11d. may be entered. On the right-hand side of the machine is a total control keyboard. These control keys are used to select the registers into which the amounts are to be added or subtracted and also the columns in which information is to be printed. As usual, debits are printed



Account cards placed on the printing table of the Post-Tronic are fed into the machine automatically

in red, and credits in black, the appropriate colour being selected automatically. Totals up to a value of £99,999,999 19s. 11d. may be accumulated in any of these registers.

Registers are provided for holding the following totals: debit pick-up balances, credit pick-up balances, debit postings, debit error corrections, credit postings, credit error corrections, debit balances and credit balances. There is also a row of keys used to identify the type of transaction.

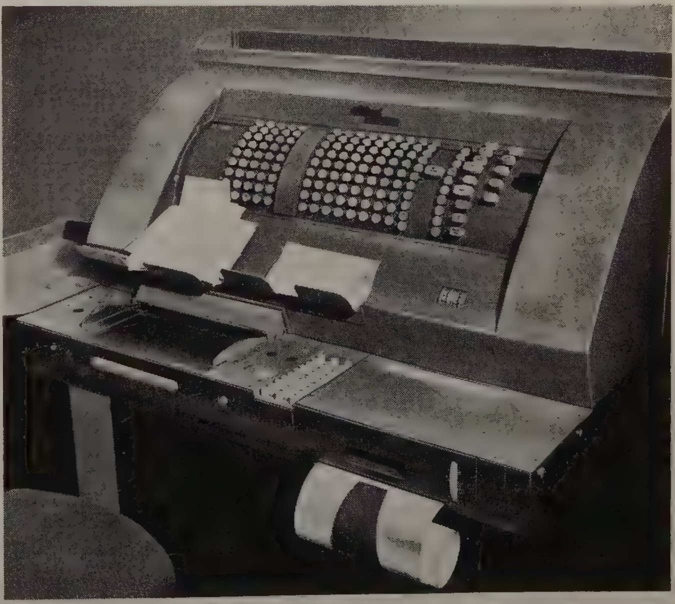
At the beginning of the day the date is set on four wheels provided on the machine and is printed automatically as part of each entry on all three documents—the ledger card, the statement and the journal sheet.

The other controls include a "correction" key, various activity counters, keys for overriding the automatic functions of the machine and a programme selector.

For normal postings, the operating sequence is as follows:—The operator selects the combined ledger card and statement by reading the customer's name and enters on the comparator keyboard the last three digits of the account number displayed on the cheque or deposit slip. She then places the card on the printing table of the Post-Tronic and presses the "feed" key. As the card is fed into the machine, the electronic heads read information from the magnetic ink stripes on the back of the card. The last three digits of the account number are checked with those entered on the comparator keyboard and, if they agree, the card is moved into the printing position. All this is done automatically.

If the data are not in agreement, the machine locks and a warning light comes on. The operator then has to rectify the error by either

Arrangement of keyboard on the Post-Tronic



replacing the ledger card with the correct one or re-entering the last three digits of the customer's account number. After the ledger card has been fed into position the amount is entered on the amount keyboard. When the operator touches the appropriate transaction key (e.g., "cheque" or "deposit") this amount is posted to the account and the details of the entry are printed on the ledger card, statement and journal sheet simultaneously. Finally, the new balance is calculated and, when another key is pressed, printed. This allows multiple items to be entered on the account documents before the new balance total is printed. At the same time, the up-dated balance is recorded magnetically on the back of the card.

At the end of the posting run, all control totals and sub-totals are cleared from the machine by pressing the appropriate keys and, simultaneously, these figures are printed on the journal sheet. These totals can then be checked immediately against the corresponding control totals obtained from a previous listing and proving operation.

If a ledger card is filled during a multi-item posting, the balance and other data can be carried over to a "continuation" card without the necessity of making any additional manual entries.

When statements are to be issued, the balances and account numbers are transferred to a new set of ledger cards by using the machine with the programme selector in the data "transfer" position. The old card is placed in the machine and the magnetically recorded data are read from it and stored within the machine. The card is then removed and replaced by a new card. The current data held in store is recorded on the back while the corresponding information is printed on the front.

Trial balance

The listing and accumulation of balances for the trial balance is performed in a similar way. The operator inserts the cards one by one, the current balance is read from each card in turn and the total is accumulated in one of the machine registers.

When the operator sets the programme selector in yet another position, the electronic functions of the machine can be suspended and this enables the Post-Tronic to be used as a conventional accounting machine for manual add and subtract listing operations.

In the new fully automatic Post-Tronic, manual keyboard operations are dispensed with altogether. Account numbers and amounts are fed into the machine on punched paper tape obtained as a by-product of electronic document sorting or of conventional proof listing operations. For this purpose a proof or add-listing machine is electrically coupled to an automatic paper tape punch. An automatic ledger card feeder is also fitted to the fully automatic Post-Tronic; this holds up to 1,000 ledger cards and feeds them, one by one, on to the printing table.

Development of system

The possibility of, ultimately, being able to convert to a fully automatic system of this sort had some influence on the Chartered Bank's decision to install semi-automatic Post-Tronics. When this decision was taken, the Bank was actually in the process of replacing its conventional accounting machines, which had been in service for the previous ten years, with

The date is set on four rotary dials

newer versions of the same machines. However, this three-year replacement programme was suspended because the management wanted to explore, more fully, the data processing facilities that were being brought within reach of those banks which certainly could not afford to install electronic computers costing hundreds of thousands of pounds. And as a direct result of this investigation the National Cash Post-Tronics were ordered.

The Chartered Bank is mainly concerned with trade in the Far East and was founded in 1853, following the abrogation of a monopoly, held since 1600, by the East India Company. With its subsidiary, The Eastern Bank, it now has over 100 branches in 25 territories from Cyprus to Japan. During the past decade its business has grown considerably and this has naturally thrown more work upon the head office, in London.

At the head office the ledgers are divided into 15 sections, each of which has until now been handled on one mechanical accounting machine. An average ledger contains about 800 accounts.

Staff

The growth of the business has naturally produced staff problems. One of these is concerned with the recruiting and training of accounting machine operators. With conventional equipment and posting methods the operator has to select accounts by identifying the customers' signatures. Obviously it takes her some months to become familiar with the hundreds of signatures in the ledger section for which she is responsible, and for this reason staff turnover represents a considerable loss to the bank in operating experience.

Also, errors in account selection are most likely to occur when an operator is new and is therefore tempted to ask the opinion of one of her colleagues rather than refer doubtful cases to her supervisor. Such errors have, of course, a bad effect on the bank's relations with its customers as well as holding up routine operations, further, a considerable amount of unproductive work is involved in tracing and correcting the mistakes.

Like other British banks, the Chartered Bank safeguards itself in this respect by using a double-posting system. After a batch of cheques, deposit slips or other input documents have been listed to provide control totals, they are posted first to the ledger cards and then, in a separate run, to the corresponding statements. Unfortunately, experience has shown that it is possible for the accounting machine operator posting the statement to make the same mistake as the operator posting the ledger. The Post-Tronic system, with its automatic verification of account selection and balance pick-up, eliminates this danger, also the simultaneous posting of ledger card and statement speeds up the work considerably.

Mechanical counters (on the left) record the number and type of transaction entries made

The Post-Tronic verification system is based on the customer's name and account number being printed on each cheque. Indeed, the customer's account number must appear on every document which records a transaction affecting his account. Personalization of cheques is a pre-requisite of nearly all developments in bank automation and is already used to some extent in Britain. From the experience of the past few months, the Chartered Bank believes that because cheque personalization simplifies document sorting and other work, and also reduces the risk of error, it is capable of producing valuable savings in time and effort even where conventional methods of account posting are used.

Nevertheless, the bank sees no purpose in subjecting customers to such changes while the new equipment is being settled in; consequently, for the moment, the two Post-Tronics have been restricted to internal bank accounting activities. Members of the staff have been instructed to use their account numbers on all documents, and there is no difficulty in making good the comparatively small number of omissions which do occur. When the new system is extended to customer's accounts, the bank will have to set up a special section to print the appropriate headings on the documents used.

Preparing documents

The present system of preparing documents is quite simple. Identifying data are printed on the top of each combined ledger card and statement by an addressing machine, replacement ledger cards being prepared whenever new cards are issued to the Post-Tronic operators. Also, before any Post-Tronic operations are performed all cheques and other input documents are pre-listed on adding machines to obtain the necessary control totals.

The Chartered Bank took steps to evaluate the performance of the Post-Tronics under normal working conditions. About six months before the new machines were installed, a statistical survey was made of the operations performed on the ledger sections scheduled to be transferred to the new machines. This was done without preparing the accounting machine operators in any way. Consequently it is possible that higher working speeds could have been obtained under peak operating conditions. A similar survey was made soon after the Post-Tronics had taken over the work.

Speed of operation

In both cases the duration of the survey was one month. For the purpose of comparison, the recorded times have been reduced to "seconds per item posted" to allow for differences in the volume of work. The time spent on setting up the machine, preparing the posting trays, referring queries to the supervisor and so on are included in the figures.

Because of the age of the existing machines, the "pre-Post-Tronic" speeds are not as high as they might have been but this is counterbalanced, the bank believes, by the fact that the new set of speeds were recorded when the operators had very little experience on Post-Tronics.

With mechanical machines, it took an average of 60 seconds to post each item to the ledger card and statement. The Post-Tronics cut this time to 16·47 seconds—a saving of over 70 per cent.

The time spent on balancing the ledger totals with those provided by the pre-listing of input data represented 4·1 seconds per item for conventional machines and 1·09 seconds per item for Post-Tronics (the latter figure would have been much better had it not been for incorrect pre-list entries).

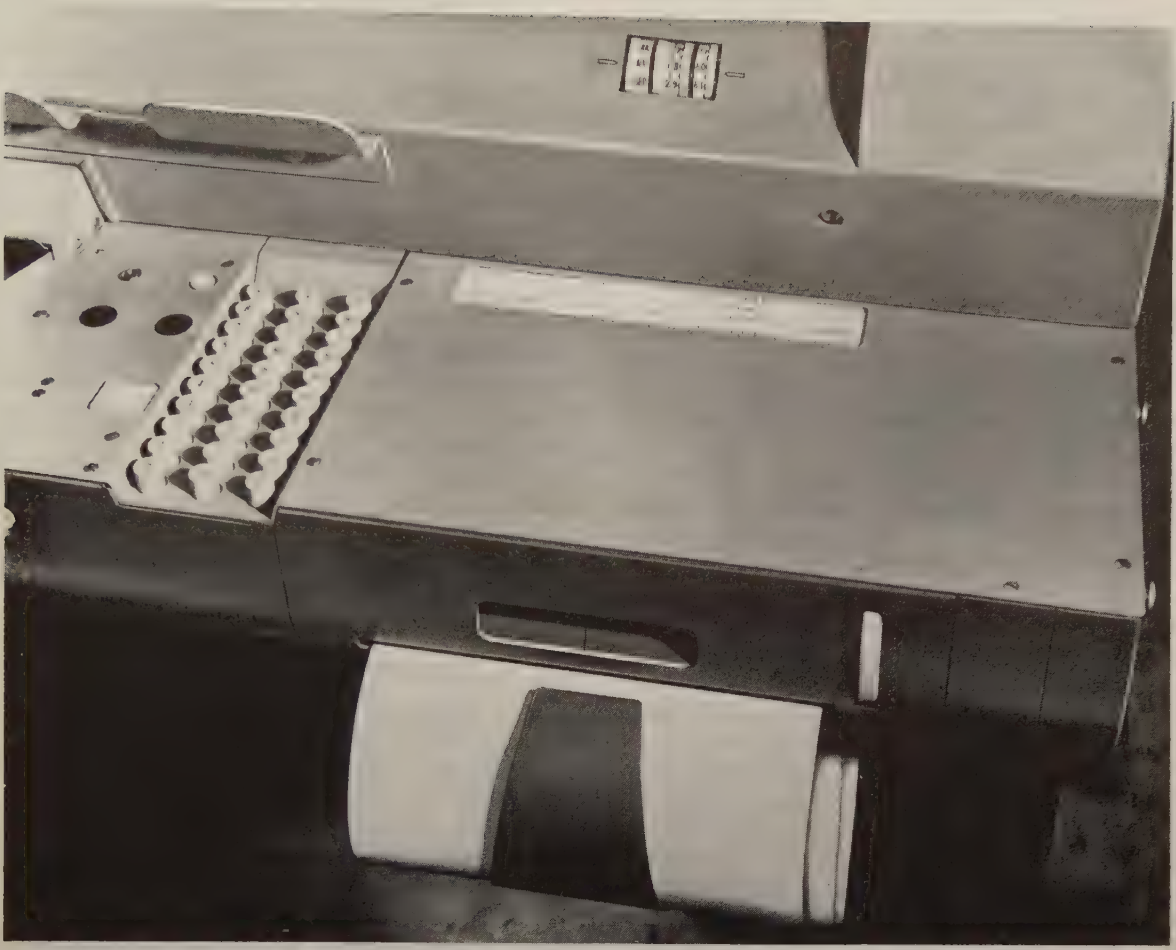
Similar results were obtained during the weekly trial balance procedure. The actual time taken to select and read the current balance from a ledger card was 8·4 seconds for a conventional machine and 3·47 seconds for a Post-Tronic. Moreover, because of the inherent accuracy of the Post-Tronic balancing time was cut from 4·33 seconds per item to 0·13 seconds per item.

Work capacity

At present, the two Post-Tronics are doing the work of three conventional machines but this does not keep them fully employed. A survey is being made to find out whether further changes in procedure are desirable. It is thought that the introduction of deferred posting—where each day's transactions are posted to the combined ledger card and statement on the following day—will enable the work to be performed more economically. It is also considered that if deferred posting is introduced this would enable the existing Post-Tronics to take over the work of two additional accounting machines and still leave a reasonable safety margin for dealing with periods when the work load reaches a peak.

Under the present "same day" system, the postings are completed in fairly small batches, but even so the Post-Tronics are idle during a large part of the morning. (With conventional machines two separate up-dating operations were necessary; the ledgers were posted during the afternoon and the corresponding statements produced the following morning.)

Because Post-Tronic statements are restricted to figures and symbols, the extension of the new system to customers' accounts will necessitate additional changes. At present, a narrative description is given of all transactions involving



A complete record of each transaction is printed on the journal sheet and the most recent entries are displayed in an aperture provided on the control desk of the machine

documents other than cheques. The problem in future will be to find an economical "off line" method of providing the customers with this information to amplify the cryptic identification symbols printed against different types of transaction by the Post-Tronic. Once again, this development conforms with the generally accepted trend in bank automation.

On the basis of experience already gained, the Chartered Bank estimates that five or six Post-Tronics could eventually take over the entire work previously handled on 15 mechanical machines. This, in turn, would lead to a big saving in staff.

Another advantage is that Post-Tronics are easier to use than conventional accounting machines and operational dexterity can be gained in a couple of days or so. Moreover, the fact that machine operators do not have to identify accounts by referring to the customers' signatures means that girls with considerably less practical experience of the Bank's routines can still be employed effectively, and this goes a long way towards solving the problem arising from staff turnover. The bank also finds that operators like the machines because they are less tiring to use.

Above all, there is evidence that, in spite of the speeding-up of the work, the new equipment leads to a higher degree of accuracy and, in consequence, better service to the customers.

It is this feature in particular which is likely to interest other branches of commerce. Although the Post-Tronic has been designed primarily for bank work, it has potential applications in such organizations as building societies and finance houses. Moreover, the new principles it employs may well be incorporated in more general types of data processing equipment.

Data processing topics

Exhibitions and symposia

An international seminar is to be held in Brussels from November 21st to November 23rd inclusive on the subject of analogue computation applied to the study of chemical processes. The seminar is being organized by the Institut Belge de Regulation et d'Automatisme, 43, rue de la Science, Brussels 4, Belgium.

The 48th National Business Efficiency Exhibition at Olympia, London, is to be held from October 3rd to October 12th. More than 150 firms will be represented. Among the exhibits will be an I.C.T. 1202 computer, the new I.C.T. 915 tabulator and an I.C.T. 555 plugged programme computer. IBM will have on show the new 084 2,000 cards-a-minute sorter, a 1620 scientific computer and a 1401 data processing system equipped with magnetic tape. The latest Logabax multi-register keyboard accounting machine will also be there. This model is equipped with 58 totalling registers arranged in two banks—49 registers in one bank and nine in the other.

Next year, an Electronic Computer Exhibition will be held in Great Britain—at Olympia, London—from October 4th to October 12th. A Business Computer Symposium will run concurrently. This will be the second computer exhibition to be held in Great Britain. The first was in November, 1958.

Computers for insurance work

Like the Prudential Assurance Company Limited, the Norwich Union Life Insurance Society is also to have a Ferranti Orion data processing system. The installation, which will cost more than £250,000, is scheduled to be in operation by January, 1963. Initially, the computer will be used for administering pension schemes operated by the Company; later the work of maintaining 350,000 individual policy records will be transferred to the machine.

The Yorkshire Insurance Company Limited is also to have a computer. An IBM 1401 has been ordered. Recently, it was announced by IBM that the capacity of the core store of a 1401 system may now be increased to hold a maximum of 16,000 characters.

Analogue-digital computer

Both analogue and digital computing techniques are used in a new design of computer called Radic (Redifon Analogue-Digital Computer). Calculations are performed by analogue computing elements, while digital devices are used for data input, output and storage purposes.

The system will be able to solve problems connected with the automatic control of industrial processes. Built by Redifon Limited, Crawley, Sussex, England, a Radic system will range in cost from about £10,000 to £150,000.

Computers for British banks

Following upon the order of a Burroughs B101 sorter-reader (costing £35,000), Lloyds Bank Limited have announced that three IBM 305 Ramac computers are to be installed in their Pall Mall, London Branch—the largest branch bank in Great Britain. It is estimated that the three machines will be able to keep the records of 60,000 accounts and post 100,000 entries a day. The complete computer installation will cost £350,000.

The National Provincial Bank Limited has opted for a Ferranti Orion data processing system which it is stated will be capable of administering 150,000 current accounts. This installation will cost over £200,000.

High-speed computers—Stretch and Atlas

Two of the fastest computers in the world are the IBM Stretch and the Ferranti Atlas. IBM has announced that Stretch class computers will be built under contract for business firms and government agencies. Cost of Stretch systems is reported to be from £3·5 million upward. The United Kingdom Atomic Energy Authority has signed a contract for one of these machines which is scheduled to be installed towards the end of 1961. A random-access disc store will be fitted as well as an extensive magnetic tape system. Stretch is said to be from 75 to 100 times more powerful than the IBM 709 at present used by the United Kingdom Atomic Energy Authority.

The Atlas computer is being designed and developed jointly by Ferranti Limited and a team at the University of Manchester. The first machine will be completed early in 1962 and is to be installed at the University, where it will be used primarily for scientific research. It will also be available for hire. A typical Atlas installation costs from £1 million to £3 million depending upon the application. Some idea of the tremendous calculating speed of this machine can be gained from the fact that an addition can be completed in little more than a microsecond (0·000001 second), while the more lengthy process of multiplication is performed in four microseconds (0·000004 second).

New computers

Leo III is a transistor computer now under development at the Acton (London) factory of Leo Computers Limited. The first production model is expected to be finished by the middle of 1961, and the first commercial installation is to be completed and working by April, 1962. Typical time for addition or subtraction is 44 microseconds (0·000044 second). A magnetic-core store capable of holding up to 327,680 decimal digits can be provided and high-speed magnetic tape units may be fitted. Two or more programmes can be run concurrently.

A new version of the National-Elliott 803 has been introduced for business and general-purpose applications. A magnetic-core store that can hold 50,000 decimal digits is provided and a magnetic-film data file of one million computer words capacity is also fitted. Input data are read from punched paper tape and punched cards or may be entered on a decimal keyboard. The central computing unit of the 803 has also been incorporated in a wide range of process control systems built by Information Systems Incorporated, Illinois, U.S.A.

Svenska Aeroplan Aktiebolaget of Linköping, Sweden—the Saab Aircraft Company—have entered the computer market with a small transistor digital computer known as the D2. It is intended, primarily, for process control work and other automation applications. Addition time is 7 microseconds (0·000007 second) and multiplication takes 23 microseconds (0·000023 second).

Recording telephone charges

In Great Britain, over 800 million call tickets are written each year and 10 million telephone accounts are prepared. This huge data processing job is now to be performed mechanically and the General Post Office and International Computers and Tabulators Limited have co-operated to develop the special-purpose punched-card machines needed for this work. One of the first Mechanical Ticket Processing (MTP) units is in operation in Manchester where it is being used to process information obtained from 55 million call tickets a year. Equipment similar to that installed at Manchester has already been exported to Japan and Malaya, where the same method of recording telephone calls is to be introduced.

The data processing sequence is as follows:—When a call is made the operator marks on a 40-column card the caller's number and the charge. Marked cards are then passed through a mark-sensing punch at a speed of 90 a minute and the marked data are converted into punched holes. At the same time, certain fixed information such as the date is also entered in the cards. At specified intervals the cards are sorted into telephone number order preparatory to compiling the accounts to be sent to the subscribers.

Tickets for local calls are passed through a summarizing punch at a speed of 200 a minute and the total for each account is recorded in a summary card. Tickets for long-distance calls are passed through a tabulator which prints the date and charge for each call, and also compiles and prints the total amount. A copy of this statement accompanies the account sent to the subscriber for payment.

I.C.T.'s new computer—

An expandable fully transistorized magnetic-tape data-processing system for business applications

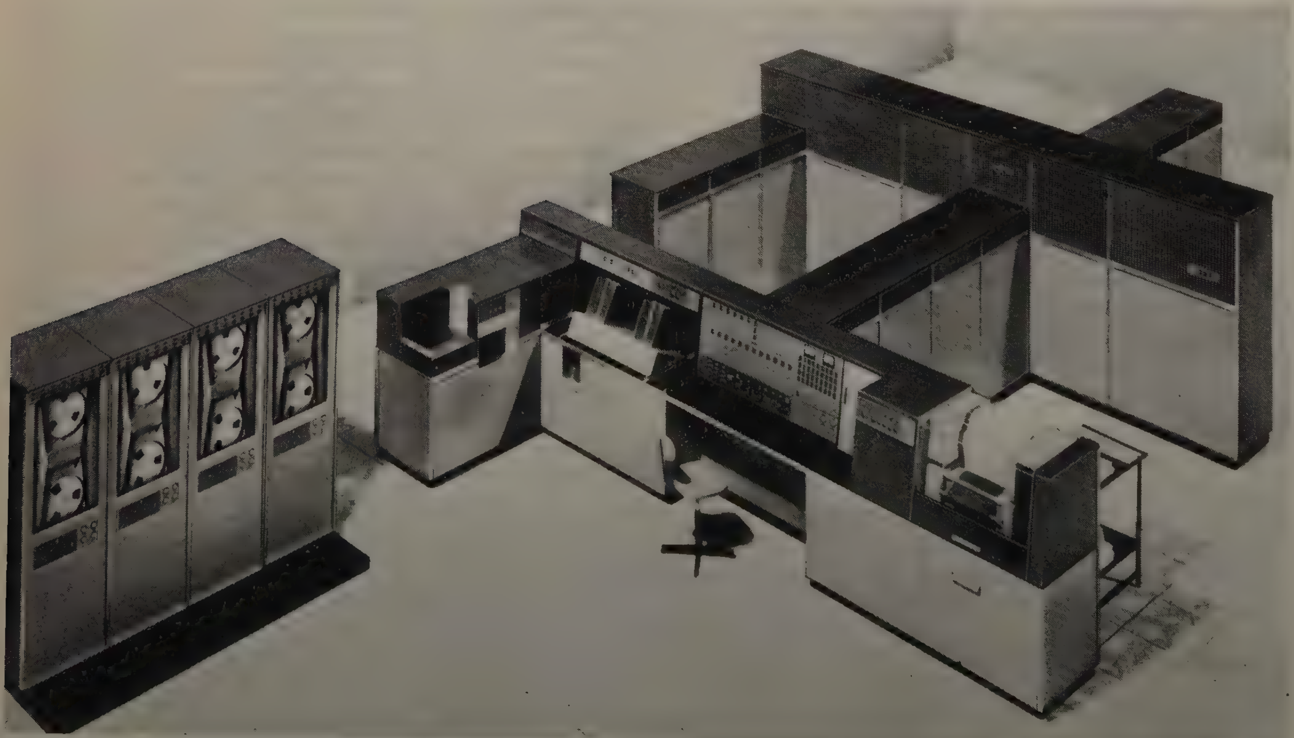
An important feature of the 1301 design is that the size of a system can be increased after the initial installation. The system can grow at the same rate as the organization which uses it. Also the speed of handling information can be increased by fitting high-speed magnetic-tape units.

The 1301 was designed and developed by Computer Developments Limited, a company owned jointly by International Computers and Tabulators Limited and The General Electric Company, of Great Britain. This is the first computer to be announced by I.C.T. since the company was formed in January, 1959, by the merging of the two punched-card firms of Powers-Samas and the British Tabulating Machine Company (better known as Hollerith).

Although details of the 1301 were only recently released, orders worth over £1 million have already been received. Organizations using 1301 systems will include banking, engineering, transport, insurance and the public health service

A COMPUTER has an almost insatiable appetite for work. This valuable attribute, however, creates difficulties for the computer designer because the volume and diversity of work to be performed vary from one user to the next and, naturally, nobody likes paying for equipment that is not utilized to the full; conversely, nobody cares to see the growth of an organization restricted by the capacity of the machines with which it is equipped. The answer to this problem is, of course, to provide an expandable system. And, although easier to specify than to achieve, this, nevertheless, is the current trend in computer design and was the philosophy adopted by Computer Developments Limited when the I.C.T.1301 was being devised.

*Model of an I.C.T.*1301 *magnetic-tape data processing installation*



As a result, I.C.T.1301 data processing systems can be tailored to suit a wide range of organizations—from those that need a fairly modest punched-card computer to those requiring a high-speed magnetic-tape data processing system. The design is so arranged that units can be added subsequently. As the organization grows, so the computer grows with it. When the volume of work exceeds that with which the simple punched-card 1301 can cope, magnetic-tape units may be fitted which permit data to be handled at much higher speeds and thereby increase the work capacity of the system by a considerable margin.

I.C.T. 1301 APPLICATIONS

User	**Application**
Cadbury - Fry - Pascall (Pty) Limited, Hobart, Tasmania.	Invoicing, stock control, general administration.
Bank (unnamed) Stockholm, Sweden	Current accounts, savings bank accounts, statistics.
AB Electroskandia, Stockholm, Sweden.	Invoicing, stock control, general accounting.
British Railways (Eastern Region), Peterborough, England.	Invoicing, traffic statistics. Ultimately this installation will be the data processing centre for the Eastern Region of British Railways.
Institute of London Underwriters, London, England.	Centralized accounting, underwriting statistics.
Rubery Owen and Company Limited, Darlaston, England	Production control, stock control.
South-West Regional Hospital Board, Bristol, England.	Hospital accounting, stores control, payroll.

Another feature of particular interest to British firms is that arithmetical calculations are performed directly in decimal or sterling. Also, the line printer provided with the 1301 prints the sterling values 10 and 11 in the space normally occupied by single decimal figures.

A basic 1301 costs £65,000 and is equipped with a punched-card reader, a card punch, a line printer, a magnetic-core store and a magnetic-drum store. A more powerful version of the 1301 punched-card computer provided with greater internal information storage capacity (four magnetic drums and a larger core store) costs about £95,000. For £120,000 a magnetic-tape data processing system can be obtained, and the price of a large high-speed magnetic-tape 1301 ranges from £170,000 upward.

Another aspect of computer operation that is receiving greater attention these days is programming. In the early days of the computer when these machines were used almost exclusively for scientific calculations it was something of an art to write a programme, but sufficient mathematicians were available to perform this work. However, when computers began to be employed more widely in engineering, and later on in business, programming became something of a stumbling block. As a result various automatic programming codes were developed to make the task of preparing the machine instructions easier. Once the concept of automatic programming had been accepted, it was not long before the idea of a universal automatic programming code, or language, was suggested. Several languages have now been developed to suit various applications and the one designed for business use is called COBOL (Common Business Oriented Language). Consequently, when I.C.T. decided to create an automatic programming code for the 1301 it was based on this international language COBOL.

The principle of automatic coding is that an instruction for the machine to perform a specified sequence of operations is given by using descriptive phrases written in plain, if abbreviated, English. Only certain words may be used, and the order in which they are arranged is determined by a set of special grammatical rules. Each individual record is given a name which is defined once only; thereafter the computer will know where to obtain the items of information referred to in the phrases. These phrases are then punched into cards and the information is fed into the computer after a special translation programme has been entered. The computer proceeds to interpret the phrases and to produce detailed instructions in the machine code. These instructions are punched in a set of output cards which are used in the subsequent data processing operation as the machine programme.

Typical instructions written in the 1301 automatic programming language and taken from a payroll calculation are:—

Add normal hours, overtime premium piece work increment giving total hours.

Calculate hourly rate for labour grade x. Total hours giving gross rounded up.

Enter subroutine (Tax routine) with code, gross B/F, tax B/F to produce tax this week, gross C/FWD. Tax C/FWD. Subtract tax this week, deductions from gross giving net.

Write pay slip on channel 6.

Some idea can be gained of the amount of manual programming work that can be saved by using automatic programming techniques when it is stated that the last but one example in the list above (Enter subroutine . . .) is converted by the computer into 423 separate machine instructions.

Other advantages

Other advantages associated with the use of automatic programming codes, besides the savings in time and expense, are:—Amendments to existing programmes can be incorporated quite simply by changing the appropriate English language statements—the computer does the rest and makes the necessary alterations to the machine programme; the time taken for programme testing and the location and correction of errors is greatly reduced; and, finally, the technique of programming can be taught quickly and can be performed by people who are not computer experts.

The only disadvantage is that a programme compiled automatically may take longer to run than a similar programme prepared manually, but this is a small price to pay for the major advantages gained.

All 1301 systems are provided with punched-card data input and output units. Both programme instructions and input data are punched in standard 80-column cards which are read photo-electrically at the rate of 600 a minute.

To confirm that the information fed into the computer is correct the cards are read twice and the data obtained compared. Obviously, if any errors or inconsistencies are detected the information is rejected. Data can be arranged in any sequence on the card; the interpretation to be placed on the various figures is determined by the programme.

The part of the programme that defines where on each card particular items of information are to be found does not, as a rule, have to be prepared manually. A number of subroutines (these are small special-purpose programmes) are available that can take care of most data input and output operations. These subroutines are inserted in the main programme in the appropriate places.

Punched-card reader

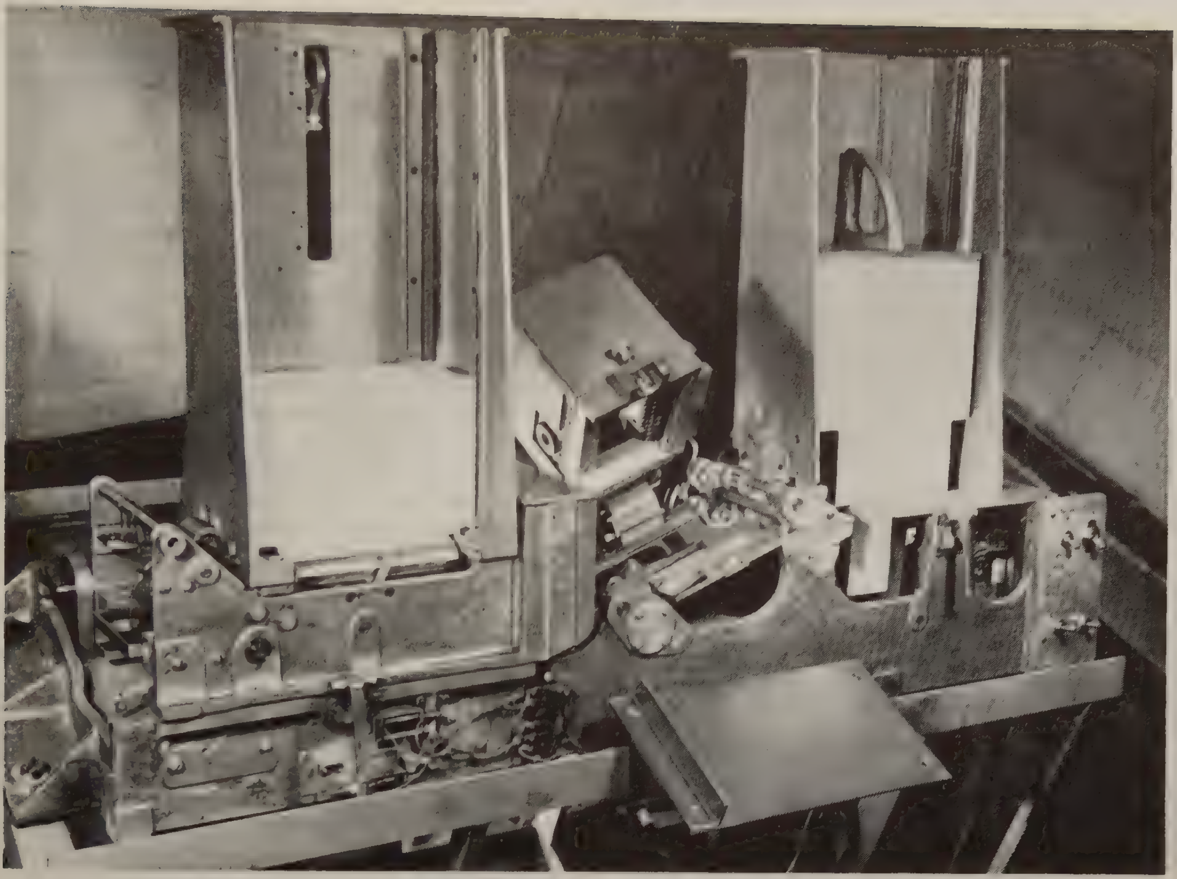
The punched-card reader is provided with three hoppers: an input hopper that can accommodate 2,000 cards, an output hopper of similar capacity and an auxiliary hopper that holds 500 cards. After being read, the cards can be diverted into either the output or the auxiliary hopper. This is a valuable facility since it enables limited sorting to be performed as part of the data input procedure. For instance, master cards can be separated from detail cards. Incidentally, the card reader senses rectangular or slotted punched holes, not round holes.

Results of computations are recorded in standard 80-column cards by the output punch at the rate of 100 cards a minute. Immediately after the results are punched, the information is read from the card and transmitted back to the computer where it is compared with the original results still held in the information store. In this way the accuracy of the results recorded in the card is confirmed.

The arrangement of the data punched in the card is controlled by the programme. As mentioned earlier, a number of subroutines have already been compiled for this operation.

The computer is so designed that time-shared operation of the units is possible. For example, the card reader and punch can both be operating simultaneously at full speed.

Another data recording device fitted to a basic 1301 system is a line printer. This is an entirely new unit developed specifically for the 1301. It is not an adaptation of an existing punched-card tabulator. With this unit, data are printed at a speed of 600 lines a minute. Any one of 50 different characters may be printed in any or all of the 120 positions available in a line. The printing head consists



Punched-card reader. Cards are read photo-electrically at a speed of 600 a minute

of a barrel comprising 120 typewheels locked together and rotating at 800 revolutions a minute. On each wheel are engraved the 50 characters. Included among these are the numbers 0 to 11, the alphabet and various other symbols.

Continuous stationery is fed between the rotating print barrel and a line of 120 electrically actuated hammers—one opposite each typewheel. An inked ribbon runs between the print barrel and the paper and whenever a specified character comes into the correct printing position the appropriate hammer is operated to bring the paper into contact with the typewheel and so produce a printed impression on the paper. Printed characters are spaced horizontally, ten to the inch, and vertically, six to the inch.

The sprocket tractors that engage with the perforations down the sides of the continuous stationery and feed it into position can be adjusted laterally to accommodate any documents within the limits of 6 to 16·5 inches in width. Three carbon copies of each document in addition to the top copy can be produced.

Format of the printed data and the movement of the paper are controlled by the computer programme. When the last line has been printed on one document, time can be saved if the paper is moved or "thrown" at high speed to bring the first line of the following form rapidly into the printing position. This facility is provided on the 1301 printer and the paper is moved at a speed of 400 feet a minute during these high-speed skipping operations. A photoelectric mark-sensing device is fitted to the printer to ensure that the new form has been fed to the correct position before printing is allowed to start.

Naturally, the actual printing speeds achieved will depend upon the job performed. When producing lists of information read directly from punched cards, the printer operates at a speed of 570 lines a minute.

There are three methods of storing information within a 1301 system—magnetic cores, magnetic drums and magnetic tape. Magnetic cores provide the immediate access memory and also the working store. A basic 1301 system is equipped with a core store of 400 computer words capacity. In conformity with the design philosophy that the system must be expandable, the capacity of the core store can be increased in increments of 400 words up to a maximum of 2,000 words.

Computer word

A 1301 word may contain either 12 decimal digits or 12 digits plus a check digit. All calculations are performed with words 12 digits long. However, when a word is to be sent to either the core store or the magnetic drum a check digit is created and added to the word to confirm that it has been entered into the store correctly. Later, when the word is taken from the store, the check digit is used to confirm that it has been read correctly. After this the check digit is discarded. Check digits are only used in data transfer operations.

All information is handled within the computer in decimal binary form*. A 4-bit code is used. When alphabetical data are being handled, two 4-bit code groups are used to represent each character.

All information transferred between the core store and other units in the system pass through a single word register known as register A. This register receives the 48 bits of a basic computer word from the auxiliary unit in a sequence of 12 4-bit groups. When the register is full, all 48 bits are transferred simultaneously (in parallel) to the core store. The converse operation is performed when data are transferred from the core store to an auxiliary unit. The information is received in parallel from the store and then transmitted in serial-parallel form to the auxiliary unit. Access time to any word in the core store is, in effect, zero.

Every 1301 computer is equipped with at least one magnetic-drum store, although a total of up to eight drums may be fitted either when the system is installed or later. One drum accommodates 12,000 computer words on 60 recording tracks. Two further tracks are provided on each drum for special-purpose programmes such as engineering test routines or for converting relative addresses into absolute addresses. Information may be read from these two tracks at any time, but the data recorded

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*For an explanation of decimal binary codes, see "The universal language of computing," *Data Processing*, January-March, 1959.

I.C.T. 1301 COMPUTER CHARACTERISTICS

Numbering system:	binary coded decimal. 4-bit code for decimal numerals, 8-bit code for alphabetical characters.
Mode of operation of arithmetic unit:	serial-parallel, 4-bits in parallel.
Times for arithmetical operations:	
+ and —	21 microseconds (0·000021 second).
×	170 microseconds (0·00017 second) for each digit in the multiplier.
÷	by programme.
Type of instruction:	single address.
Basic word length:	12 decimal digits (48 bits).
Quick access store:	magnetic core. 400-words capacity which can be expanded in 400-word increments up to a maximum of 2,000 words.
Main store:	magnetic drum of 12,000 words capacity. Up to 8 drums may be fitted.
Backing store:	magnetic tape. From 1 to 8 magnetic-tape decks may be fitted. Either a standard system or a high-speed system can be used.
Data input:	punched cards read at 600 a minute. magnetic tape. Standard system, 22,500 decimal digits read per second. High-speed system, 90,000 decimal digits read per second.
Data output:	cards punched at 100 a minute. printed at 600 lines a minute with 120 characters in each line. magnetic tape. Standard system, 22,500 decimal digits recorded per second. High-speed system 90,000 decimal digits recorded per second.
Number of 1301 systems on order:	15.

there is protected; it cannot be erased or overwritten unless the service engineer arranges for this to happen.

The drum rotates at 5,240 revolutions a minute and data are transferred between the drum and the core store in blocks of ten words called decades. The average access time to a decade stored on the drum is 5·7 milliseconds (0·0057 second).

Magnetic tape

Finally, data may also be recorded and stored on magnetic tape. Two magnetic-tape systems are available—a standard system and a high-speed system. A 1301 can only be equipped with one of these systems. It is not possible, in the same installation, to mix standard and high-speed units, although in any one installation from one to eight magnetic tape decks may be fitted.

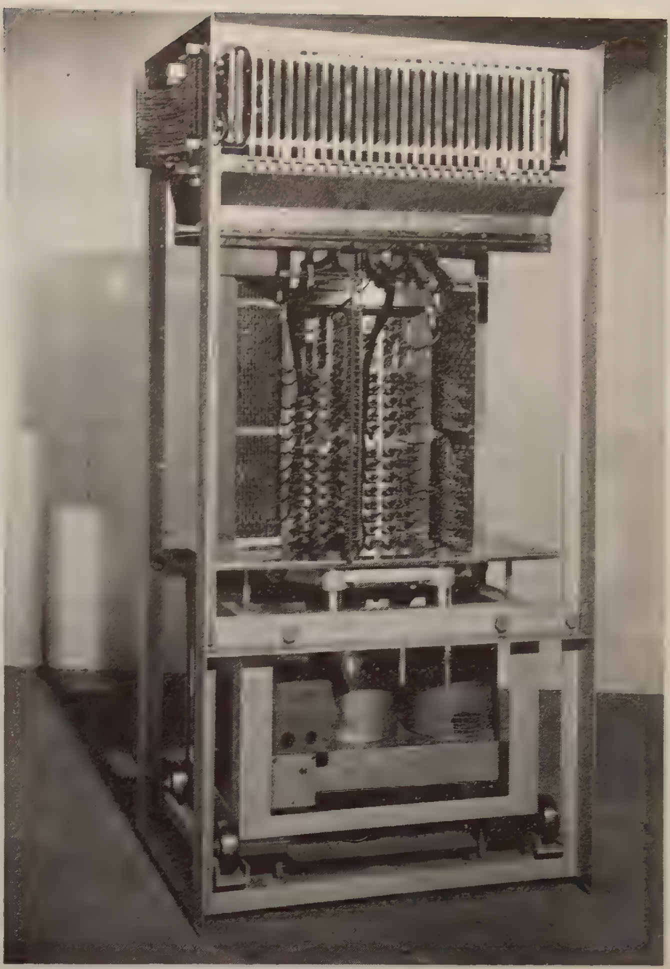
Magnetic tape half an inch wide is used in the standard system. Ten tracks are provided—four for data and six for checking information. Decimal digits are recorded at a density of 300 per inch and, since the tape speed is 75 inches a second, an instantaneous data transfer rate of 22,500 decimal digits a second is achieved.

With the high-speed system magnetic tape one inch wide is used on which 16 recording channels are provided—eight for data and eight for checking information. The recording density is 600 decimal digits per inch and the tape is run at a speed of 150 inches per second. Consequently, the instantaneous data transfer rate is 90,000 decimal digits a second; four times faster than the standard system.

Data checking system

The large number of checking channels provided on the magnetic tape of both systems enables single bit errors in any 4-bit decimal code group to be identified and corrected automatically. Double errors may also be detected, but cannot be corrected automatically, although the block will be automatically re-read.

Data can be read from one magnetic tape, results recorded on a second magnetic tape and computations performed by the central computer, all simultaneously. This is possible because a register which stores one word is provided between the magnetic tape unit and the core store to hold information in transit. When the register is full the main programme is automatically interrupted for 15 microseconds (0·000015 second) to allow the accumulated data to be transferred.



12,000 *words can be stored on a* 1301 *magnetic drum*

Another useful facility provided on the 1301 is a magnetic-tape queueing system. When large magnetic-tape files are being processed, any two consecutive reels of a file may be fitted on two different magnetic-tape decks and the "operate" buttons of these units are pressed —manually—in the required sequence. Data on reel 1 will be processed first and, when the re-wind order is reached at the end of this tape, work will automatically begin on the data recorded on reel 2. While this is going on, reel 1 is re-wound and replaced by reel 3. Thus, data processing is performed continuously and is not interrupted by manual reel-changing operations.

Each reel can hold up to 3,600 feet of magnetic tape and data may be recorded in variable length blocks.

In conformity with modern practice, transistors and printed circuit boards are used.

Management accounting

a technique that enables better administrative

A Ferranti Pegasus computer is used by Dewrance and Company Limited for comparing, month by month, the actual production output and expenses of two factories with the figures specified in each factory's yearly budget. As a result, the management can maintain precise control over the activities of the production departments and also over sections within these departments. Any adverse trends can be detected as soon as they develop, enabling corrective action to be taken at an early stage.

Basic data in the form of budget figures for fixed expenses, variable expenses and manufacturing output are supplied to the computer, together with current data of the actual production achieved and the expenses incurred. Before the two sets of figures are compared, the variable expenses of the budget are adjusted to correspond with the output achieved by the factories. Then, detailed comparisons are made and the results printed out in the form of expense and production performance variances.

Previously, these calculations were performed manually. Now that a computer is used, more detailed and precise information is obtained because, among other things, the variable budget expenses are adjusted more accurately than was the case with the manual procedure

Dewrance and Company Limited use the Ferranti Pegasus computer of their parent company Babcock and Wilcox Limited. The management accounting programme is one of 70 that are run regularly on this machine

by digital computer

control to be maintained over the production organization of an engineering company

Dewrance and Company Limited use a Ferranti Pegasus computer for approximately one and a quarter hours each month to produce operating statistics for production management. The Company manufactures industrial flow valves and allied equipment at two factories—one in London, the other in Dumbarton. Each factory is divided into a number of production budget centres and each budget centre is further sub-divided into a series of cost centres. A budget centre generally corresponds with a production department in which one particular manufacturing process is performed such as welding, assembly or machining. A cost centre comprises a machine or operator, or a group of machines or operators, within a department performing similar work at similar costs. For example, the drilling machine shop comprises a budget centre and the multi-spindle, radial and vertical drilling machines are three cost centres within this budget centre.

Fifteen production budget centres sub-divided into 82 cost centres, three service budget centres, a general works budget centre and a chief engineer's budget centre were established for the London factory. The Dumbarton factory comprises eight production budget centres sub-divided into 46 cost centres, two service budget centres and a general works budget centre.

Included under the heading of service budget centres are departments such as the tool room and the electrical and building maintenance departments. The general works budget centre comprises works management and the progress, planning and buying departments, while the chief engineer's budget centre includes the design, research and development sections and the departments that provide after-sales service and laboratory facilities. Unlike the production budget centres, the service, general works and chief engineer's budget centres are not further sub-divided into cost centres.

Naturally, the £ is used as the unit for expressing expenses, and output and productive capacity are quoted in hours. Three different hourly units are used—shop hours, operating hours and standard hours. Shop hours are those hours available during which work can be performed. In a standard working week this amounts to 42 hours for each machine and each operator. However, time will be lost because of failures of equipment, shortages of materials and similar operational reasons; these unproductive hours are deducted from the available shop hours and the resulting figures are referred to as operating hours. The work produced during the operating hours will also depend upon the efficiency of the man or department; hence, production output is measured in units known as standard hours. Standard hours, therefore, equal the operating hours multiplied by the appropriate efficiency factor.

As certain overhead expenses vary in proportion to these three different hourly units, they are all used in the management accountancy calculations.

Preparing the budget

Every year a budget is prepared. In this the following figures are quoted for each production budget centre: output measured in hourly units, the expense of the direct labour and the expense of the direct overheads. Direct overheads are those expenses, such as jigs, tools and consumable stores that are chargeable to the budget centre alone.

In addition to these expenses, of course, each production budget centre also has to bear its proportion of the indirect overheads represented by the service, the general works and chief engineer's budget centres. Service budget centre expenses are allocated to production budget centres in proportion to their maintenance requirements in previous years. General works expenses are allocated on a basis that befits the type of expense. For example, rates are allocated on the basis of floor area, and supervision costs are allocated on the basis of the number of personnel employed in a department.

Chief engineer's expenses are shared between the two factories in proportion to their sales turnover and are allocated to production budget centres in proportion to, in some cases, the output measured in standard hours and, in others, on an arbitrary basis.

Similar budget estimates containing similar data are also prepared for each cost centre. Naturally the cost centres have to bear their proportion of the overheads, both direct and indirect, that are incurred by, or allocated to, the particular budget centre of which they form part. Therefore, the following information is given for each cost centre: shop hours, operating hours, standard hours, expense of direct labour, allocation of direct budget centre expenses, allocation of service expenses, allocation of general works expenses and allocation of chief engineer's expenses.

Fixed and variable expenses

All expenses are identified as being either variable or fixed; that is, the expense changes with production output or remains constant. Typical variable expenses are electrical charges and consumable stores. Typical fixed expenses are rates and depreciation of buildings. The variable expenses are further classified to indicate whether they vary with shop, operating or standard hours.

Every year Dewrance prepares this budget in which all the items of information described are given for each budget centre and each cost centre. These figures are assessed on the basis that each factory works a standard 42-hour week—no allowance is made for overtime working. Also, direct labour costs are based on the current rates of pay in force at the time the budget is prepared.

Budget information for both the London and Dumbarton factories is then sent to the computing centre where it is punched into 5-channel paper tape. And this tape is used to enter the information into the Pegasus computer.

As the budget information is read into the machine it is first checked and then recorded on a reel of magnetic tape. Occasionally it is necessary to amend the budget data and this can be done, but, in general, the information recorded on the magnetic tape remains unaltered throughout the budget year.

Data are recorded on the tape in sections containing 32 computer words each. A Pegasus word comprises 39 bits; thus each section holds a maximum of 1,248 bits. The first hundred sections recorded on the magnetic tape are the management accounting programme. Following this are 400 sections containing the budget data for the London and Dumbarton factories in that order.

Once a month, figures of the actual hours produced by each of the cost centres and the actual expenses incurred by each of the budget centres are compiled and are entered on a current data list. Three additional items of information are included on the list: a single digit that indicates whether the information refers to the London or Dumbarton factory, the month number and an item called the calendar factor.

Because of holidays and the calendar, the number of working days obviously varies from month to month. This means, of course, that the current month's figures cannot be compared with one-twelfth of the gross values given in the yearly budget. Consequently, the calendar factor is included to show exactly what proportion of the year's budgeted production should have been achieved during the month under consideration and also what proportion of the expenses should have been incurred.

The current data lists are sent to the computing centre, where an operator using a Creed punch transcribes the information into 5-channel paper tape and a second operator, using a Creed verifier, repeats the procedure to confirm that the transcription has been completed correctly. Transcription and verification take approximately one and three-quarter hours.

Before the main programme is run, a test programme is performed. This checks the input data for compatibility and also confirms that various control totals agree. A space is left at the bottom of each current data list in which is entered a check sum that is the total of all the figures written on the sheet. These check sums are punched in the paper tape together with the other data. As the test programme is run, the computer totals the figures read from the paper tape and compares the result with the check sum when it arrives. If these two figures agree, it is reasonably certain that all the data have been transcribed and read into the computer correctly.

Besides performing the check-sum calculation, the test programme can also detect 21 other types of error.

As the information is read into the computer and is checked, the code numbers of the budget centres are punched in an output tape to indicate that everything is correct. Should an

TABLE 1

PERIOD 5 1959–60
BUDGET CENTRE 41

CALENDAR FACTOR 10.2%

STATISTICS

DIRECT LABOUR

Cost Centre No.	Activity %	Efficiency %	Capacity Usage %	Allowed Expense £	Actual Expense £	Rates of Pay Variance £	
						+	—
1	117	101	97	585	587		2
2	87	99	103	78	88		10
3	124	108	102	157	150	7	
4	121	102	103	72	77		5
5	106	98	105	6	7		1
Totals				898	909		11

error be discovered, details identifying the inaccuracy are punched in the output tape instead.

The computer completes the test programme in approximately two minutes—one minute to read the programme and one minute to read and check the data. Everything is now ready for the main management accounting programme to be performed.

The magnetic-tape reel containing the budget data is fitted to one of the four tape decks with which this particular Pegasus computer is equipped and the punched paper tape containing the current input data is threaded through the computer's photo-electric reader. First, the programme is read from the magnetic tape. This takes approximately five seconds. Then the budget data for the particular factory are read, one budget centre at a time, and the current data are obtained from the 5-channel punched paper tape.

Using the calendar factor, the computer first scales the budget data and calculates the budgeted shop hours, operating hours, standard hours and appropriate levels of expense for each cost centre for the period under review. These hourly figures are then compared with the actual shop hours, operating hours and standard hours accumulated by each cost centre and the results are quoted as three ratios known as activity, efficiency and capacity usage.

Activity is the ratio of the standard hours actually produced to the standard hours allowed; efficiency is the ratio of the actual standard hours produced to the actual operating hours worked; while capacity usage is the ratio of actual operating hours to actual shop hours. All three ratios are expressed as percentages. These ratios are calculated for every cost centre and the activity is also calculated for each budget centre.

Once the activity ratios have been obtained they are used in a calculation in which the variable expenses of the budget are "flexed" or adjusted. This is done to make the budget figures correspond with the actual levels of production achieved by the various departments within the factory. The computer determines with which type of hourly unit each variable expense is associated and calculates the expense to be allowed, based on the actual performance achieved by that particular cost centre.

After this, the computer compares the actual output and expenses with the corresponding modified budget figures. Where a difference exists, the amount of the variance is calculated and these results are recorded in 5-channel paper tape by two output punches. Printed lists are then obtained from these tapes by passing them through a mechanical reader connected to a Creed Model 54 teleprinter.

Results

The results are produced in the form of three tables. Data for tables 1 and 2 are recorded by one output punch, and for table 3 by the other.

Table 1 contains, for each cost centre: the activity, efficiency and capacity usage expressed as percentages of the budget figures, together with the allowed expense for direct labour, the actual expense for direct labour and the rates of pay variances. (A rate of pay variance is the difference between the budgeted and the actual expense incurred for direct labour.)

TABLE 2

PERIOD 5 1959–60

ANALYSIS OF VARIANCE BUDGET CENTRE 41

ACTIVITY % 113

COST RECOVERED £4,881

ACTUAL EXPENSE £4,760

TOTAL VARIANCE £121

Cost Centre No.	Volume Variance £	Extra Allowance Variance £	Efficiency Variance £	Capacity Usage Variance £	Rates of Pay Variance £
1	238	0	18	−47	−2
2	−69	0	−4	9	−10
3	43	0	49	7	7
4	47	0	5	8	−5
5	0	0	−1	1	−1
Totals	259	0	67	−22	−11

TOTAL	£293
EXPENSE VARIANCE	£−6
OVERTIME VARIANCE	£−166
TOTAL VARIANCE	£121

Table 2 shows, for each budget centre: activity, standard cost recovered, actual expense and total expense variance. These figures appear at the head of the table. Below, in the same table, the total variance is analysed by cost centres to show how it is built up—volume, extra allowance, efficiency, capacity usage and rates of pay variances are given. All these variances are expense variances and are therefore quoted in £s.

Volume variance

A volume variance is a measure of the loss in standard hours due to under-utilization of the available machines, i.e. the difference between the actual and the budgeted shop hours. An extra allowance variance is the cost of extra time allowed for completing a job because of workshop contingencies. (For instance, more material may have to be removed from a casting than was originally allowed for, because the casting is oversize or distorted.) Finally, at the foot of the table, expense and overtime variances for the budget centre are given and these figures are summed to obtain the total variance.

In Table 3 the direct expenses, both fixed and variable, for all the cost centres within a budget centre are condensed and totals for the budget centre are given. Allowed expenses are compared with the actual expenses and the variances are presented as under- or over-spending against a sequence of account numbers. Each different type of expense is given an account code number and, for ease of reference, expenses are always referred to by these numbers. For example, account number 408 is the cost of overtime premiums paid to production workers.

Incidentally, these latter expenses are included in the overtime variance. As mentioned earlier, no allowance is made in the budget for overtime; therefore, all such expenses must appear as variances. When overtime variances are compared with other production statistics, management can discover those instances where surplus capacity was available during the day, yet overtime has been worked.

To obtain the results mentioned, obviously many different types of calculation have to be performed by the computer. In addition to scaling the budget figures to suit the calendar factor and "flexing" the variable expenses to match the output achieved, another important calculation is concerned with assessing the costs recovered from each cost centre. The computer calculates the value of the fixed expenses recovered by each cost centre and attributes any under- or over-recovery to its proper cause, such as a variation in volume, efficiency, capacity usage or extra allowance. The total cost recovered from each budget centre is also calculated and this figure is then compared with the actual costs incurred and a total variance is produced.

In addition to the three sets of tabulated results already mentioned, two operating statements are produced: one for the general works department and the other for the chief engineer's department. In these statements, expenses are analysed by account number and the appropriate variances are shown.

It will be remembered that in the budget a proportion of the general works expense is allocated to each cost centre. Starting with these figures, the computer calculates a new level of allowed expense based upon the actual activity achieved by each of the cost centres. Totals are then produced for the budget centres. From these figures and the actual expenses incurred, the variances are obtained and, as stated previously, are printed as a separate statement. An operating statement for the chief engineer's department is produced in a similar manner. In this case the calculation is somewhat simpler as the department does not have any variable expenses.

No variance associated with the general works and chief engineer's departmental expenses are shown in the results produced for the individual budget centres. This is because a budget centre has no control over these expenses and therefore it would be inappropriate to include these figures in any table of results intended to show how the budget centre performed.

It has already been mentioned that the results punched in paper tape are converted into print by a teleprinter. Results are punched in tape at the rate of 30 characters a second and the printed records are produced at the rate of seven characters a second. An interesting feature of this operation is that the lists are printed on translucent drawing paper. Any number of copies can then be made by dye-line printing—the technique used for preparing engineering prints. This is especially useful because com-

TABLE 3

PERIOD 5 1959–60

DIRECT EXPENSES BUDGET CENTRE 41

Account No.	Allowed Expense £	Actual Expense £	Overtime Variance £	Expense Variance £	
				+	−
405	45	79	−33		1
406	59	62	−3	0	
407	0	5	0		5
408	0	130	−130	0	
410	4	5	0		1
411	76	62	0	14	
412	47	37	0	10	
413	23	13	0	10	
414	359	343	0	16	
416	4	2	0	2	
417	270	289	0		19
418	1	4	0		3
420	79	173	0		94
421	5	0	0	5	
422	1	0	0	1	
423	83	38	0	45	
425	72	71	0	1	
456	57	44	0	13	
G.W.	2,124	2,124	0	0	
C.E.	370	370	0	0	
Totals	3,679	3,851	−166		6

It will be noted in the above that there are no allowed expenses for Account numbers 407 and 408. 407 is the additional cost of wages on jobs which go into debt, and as such are not budgeted. 408 is the cost of overtime premiums paid to productive labour.

BABCOCK AND WILCOX LIMITED FERRANTI PEGASUS INSTALLATION

In February, 1958, a standard Ferranti Pegasus computer was installed at the head office of the Company in London. In January, 1959, the computer was fitted with four magnetic-tape units together with the magnetic-tape control console. This unit contains a buffer store of 32 computer words capacity. Information is held temporarily in the buffer store while being transferred between the computer and the magnetic-tape units, or vice versa.

One reel can hold 3,000 feet of magnetic tape and, if data are recorded in 32-word sections, up to 8,500 sections (272,000 words) can be accommodated. Data are read or recorded on magnetic tape at 600 words a second. There are 39 bits in a Pegasus word.

The Pegasus used by Babcock and Wilcox is equipped with two photo-electric readers which read data from 5-channel punched paper tape at the rate of 200 characters a second. Results are punched in 5-channel paper tape by three Creed output punches operating at 30 characters a second each. Data punched in the paper tape are converted into print at the rate of seven characters a second by feeding the tape through a mechanical reader connected to a Creed Model 54 teleprinter.

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ments can be written alongside the results on the translucent original before copies are prepared for distribution.

All the management accountancy documents sent to the computing centre and all the printed lists produced are returned to Dewrance. The only documents retained at the centre are the reel of magnetic tape on which the computer programme and factory budgets are recorded and the punched paper tapes containing the input data and the computed results for the current month. These punched paper tapes are retained for one month only and are discarded after the next month's run.

The main programme takes approximately 45 minutes to run for the London factory and about 25 minutes for the Dumbarton factory.

Work schedule

Within 36 hours of the current data being compiled, management are provided with comprehensive production and cost statistics. The input data for the monthly run are received at the computer centre on Monday. Data are punched in tape, verified and the test programme is performed the same day. On Tuesday, the main programme is run and the printed results are ready for collection that evening.

Calculations connected with sales, administration, selling and distribution budgets are also carried out by Dewrance but these are, at present, performed manually. From the statistics provided management can assess the performance of the Company as a whole.

Dewrance and Company do not possess a computer, but make use of a Ferranti Pegasus owned by their parent company Babcock and Wilcox Limited. As the head offices of both companies are situated in London, England, within two miles of each other, this arrangement is convenient.

Pegasus computer installation

The Pegasus computer was bought to perform engineering calculations and is primarily occupied on work of this nature. It was installed in February, 1958, and shortly afterwards—in January, 1959—it was modified and equipped with a magnetic-tape control console and four magnetic-tape units. These units were fitted in order that commercial work and larger engineering programmes could be handled more conveniently, and the management accounting programme for Dewrance was one of the first for which the added facility was used. More than 70 programmes are run regularly on this Pegasus installation.

The electronic digital computer is the first machine that has enabled all the calculations required in management accounting to be performed entirely automatically. A computer used in this way becomes an effective tool of management—the application in which its protagonists have always claimed it would prove of greatest value in business and industry, because no other form of mechanization is capable of providing rapidly, and in one operation, the type of information upon which management decisions can be based.